DOCUMENT RESUME

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TITLE	Environmental Support Specialist, Block V, 17-6. Military Curriculum Materials for Vocational and Technical Education.
INSTITUTION	Air Force Training Command, Sheppard AFB, Tex.; Ohio State Univ., Columbus. National Center for Research in Vocational Education.
SPONS AGENCY	Office of Education (DHEW), Washington, D.C.
PUB DATE	78
NOTE	386p.; For related documents see CE 034 965-968.
PUB TYPE	Guides - Classroom Use - Materials (For Learner) (051) -- Guides - Classroom Use - Guides (For Teachers) (052)
EDRS PRICE	MF01/PC16 Plus Postage.
DESCRIPTORS	*Environmental Technicians; First Aid; Guidelines; Lesson Plans; Military Personnel; Military Training; Postsecondary Education; Quality Control; Safety; Sanitation; *Technical Education; *Waste Disposal; *Waste Water; Water Quality; *Water Treatment; Workbooks
IDENTIFIERS	Military Curriculum Project; *Radioactive Wastes; Radioactivity

ABSTRACT

This military-developed text contains the third section of a four-part course to train environmental support specialists. Covered in the individual sections are field sanitation, classes and sources of waste, composition and characteristics of sewage, principles of sewage treatment, primary waste treatment, secondary waste treatment, tertiary waste treatment, chlorination and stream surveys, industrial and radioactive wastes, and safety practices. This section contains both teacher and student materials. Printed instructor materials include lesson plans with an outline of teaching steps and a plan of instruction detailing the units of instruction, the duration of the lesson, objectives, and supportive materials needed. Student materials provided include a study guide containing objectives, assignments, text readings, and review questions; a workbook containing exercises and lab work; and a manual on safety and first aid procedures. (MN)

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MILITARY CURRICULUM MATERIALS

The military-developed curriculum materials in this course package were selected by the National Center for Research in Vocational Education Military Curriculum Project for dissemination to the six regional Curriculum Coordination Centers and other instructional materials agencies. The purpose of disseminating these courses was to make curriculum materials developed by the military more accessible to vocational educators in the civilian setting.

The course materials were acquired, evaluated by project staff and practitioners in the field, and prepared for dissemination. Materials which were specific to the military were deleted, copyrighted materials were either omitted or approval for their use was obtained. These course packages contain curriculum resource materials which can be adapted to support vocational instruction and curriculum development.

The National Center Mission Statement

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- Operating information systems and services
- Conducting leadership development and training programs

FOR FURTHER INFORMATION ABOUT
Military Curriculum Materials
WRITE OR CALL
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Military Curriculum Materials for Vocational and Technical Education

Information and Field Services Division

The National Center for Research in Vocational Education

Military Curriculum Materials Dissemination Is . . .

an activity to increase the accessibility of military-developed curriculum materials to vocational and technical educators.

This project, funded by the U.S. Office of Education, includes the identification and acquisition of curriculum materials in print form from the Coast Guard, Air Force, Army, Marine Corps and Navy.

Access to military curriculum materials is provided through a "Joint Memorandum of Understanding" between the U.S. Office of Education and the Department of Defense.

The acquired materials are reviewed by staff and subject matter specialists, and courses deemed applicable to vocational and technical education are selected for dissemination.

The National Center for Research in Vocational Education is the U.S. Office of Education's designated representative to acquire the materials and conduct the project activities.

Project Staff:

Wesley E. Budke, Ph.D., Director
National Center Clearinghouse

Shirley A. Chase, Ph.D.
Project Director

What Materials Are Available?

One hundred twenty courses on microfiche (thirteen in paper form) and descriptions of each have been provided to the vocational Curriculum Coordination Centers and other instructional materials agencies for dissemination.

Course materials include programmed instruction, curriculum outlines, instructor guides, student workbooks and technical manuals.

The 120 courses represent the following sixteen vocational subject areas:

- Agriculture
- Aviation
- Building & Construction Trades
- Clerical Occupations
- Communications
- Drafting
- Electronics
- Engine Mechanics
- Food Service
- Health
- Heating & Air Conditioning
- Machine Shop
- Management & Supervision
- Meteorology & Navigation
- Photography
- Public Service

The number of courses and the subject areas represented will expand as additional materials with application to vocational and technical education are identified and selected for dissemination.

How Can These Materials Be Obtained?

Contact the Curriculum Coordination Center in your region for information on obtaining materials (e.g., availability and cost). They will respond to your request directly or refer you to an instructional materials agency closer to you.

CURRICULUM COORDINATION CENTERS

EAST CENTRAL
Rebecca S. Douglass
Director
100 North First Street
Springfield, IL 62777
217/782-0759

MIDWEST
Robert Patton
Director
1515 West Sixth Ave.
Stillwater, OK 74704
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Trenton, NJ 08625
609/292-6562

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Airdustrial Park
Olympia, WA 98504
206/753-0879

SOUTHEAST
James F. Shill, Ph.D.
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Mississippi State University
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Mississippi State, MS 39762
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WESTERN
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ENVIRONMENTAL SUPPORT SPECIALIST, BLOCK V

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ENVIRONMENTAL SUPPORT SPECIALIST, BLOCK V

Classroom Course

17-6

Developed by:

United States Air Force

Development and Review Dates:

September 25, 1975

D.O.T. No.:
168.168

Occupational Area:

Public Service

Target Audiences:

Grades 13-adult

Print Pages:
370

Cost:

Availability:
Military Curriculum Project, The Center for Vocational Education, 1960 Kenny Rd., Columbus, OH 43210

Contents:	Type of Materials:	Lesson Plans:	Programmed Text:	Student Workbook:	Handouts:	Text Materials:	Audio-Visuals:	Instructional Design:	Performance Objectives:	Tests:	Review Exercises:	Additional Materials Required:	Type of Instruction:	Group Instruction:	Individualized:	
				No. of pages												
Block V — *Waste Treatment and Disposal*				36												
Field Sanitation		●				●	★		●		●	★		●		
Classes and Sources of Waste		●				●			●		●			●		
Composition and Characteristics of Sewage		●				●			●		●			●		
Principles of Sewage Treatment		●				●			●		●			●		
Primary Waste Treatment with Field Trip		●				●			●		●	★		●		
Secondary Treatment with Field Trip		●				●	★		●		●	★		●		
Tertiary Treatment		●				●			●		●			●		
Chlorination and Stream Surveys		●				●			●		●			●		
Industrial Radioactive Wastes		●				●			●		●			●		
Safety Practices		●			●	●			●		●			●		

★ Materials are recommended but not provided.

Expires July 1, 1978

Course Description:

This is the third section of a four-part course to train environmental support specialists. The entire course includes training in water treatment plants, operating procedures for solid waste disposal and maintenance of water and waste processing system components. The previous sections dealt with waste processing, water analysis, and water treatment. This section discusses waste treatment and disposal. It consists of one block containing 78 hours of instruction.

Block V – ***Waste Treatment and Disposal*** contains ten lessons covering 78 hours of instruction. The lesson topics and respective hours follow:

- Field Sanitation (2.5 hours)
- Classes and Sources of Waste (1 hour)
- Composition and Characteristics of Sewage (4.5 hours)
- Principles of Sewage Treatment (8 hours)
- Primary Waste Treatment with Field Trip (16 hours)
- Secondary Treatment with Field Trip (24 hours)
- Tertiary Treatment (3 hours)
- Chlorination and Stream Surveys (5 hours)
- Industrial and Radioactive Wastes (8 hours)
- Safety Practices (6 hours)

This section contains both teacher and student materials. Printed instructor materials include lesson plans with an outline of teaching steps and a plan of instruction detailing the units of instruction, the duration of the lesson, objectives, and support materials needed. Student materials include a study guide containing objectives, assignments, text readings, and review questions; a workbook containing exercises and lab work; and a manual on safety and first aid procedures.

Several military technical manuals and commercially produced texts were also referenced but are not provided. Audiovisuals recommended for the entire four sections but not provided include twenty films, three slide sets, and one schematic diagram. This section should be preceded by **Environmental Support Specialist, Blocks I and II** (17-4) and **Environmental Support Specialist, Blocks III and IV** (17-5), and followed by **Environmental Support Specialist, Blocks VI and VII** (17-7). It can be presented in a large group instructional setting or adapted for individualized study in waste treatment or ecology courses.

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17-6

PLAN OF INSTRUCTION	COURSE TITLE Environmental Support Specialist

BLOCK TITLE

Waste Treatment and Disposal

UNITS OF INSTRUCTION AND CRITERION OBJECTIVES 1	DURATION (HOURS) 2	SUPPORT MATERIALS AND GUIDANCE 3
1. Field Sanitation a. Following written instructions, demonstrate a knowledge of proper location, construction, operation, and maintenance of facilities for disposal of waste in isolated and combat areas by writing responses to measurable written items.	2.5 (2/0.5) Day 36 (2/0.5)	Column 1 Reference: 1a STS Reference: 10a, 10b, 10c, 10d, 10e Instructional Materials SG 3ABR56330-V-1, Field Sanitation WB 3ABR56330-V-1-P1, Field Sanitation Audio Visual Aids Slides, Field Sanitation Training Methods Discussion (1.5 hrs) Performance (0.5 hr) Outside Assignment (0.5 hr) Instructional Environment/Design Classroom (1.5 hrs) Laboratory (0.5 hr) Study Hall (0.5 hr) Group/Lockstep Instructional Guidance Discuss field sanitation and facilities and show slides. Monitor student performance.

PLAN OF INSTRUCTION (Continued)

UNITS OF INSTRUCTION AND CRITERION OBJECTIVES 1	DURATION (HOURS) 2	SUPPORT MATERIALS AND GUIDANCE 3
2. Classes and Sources of Waste a. Given a list of ten waste materials, identify by written response a source of each and classify each as being domestic or industrial.	1 (1/0) Day 36 (1/0)	Column 1 Reference: 2a STS Reference: 11a Instructional Materials SG 3ABR56330-V-2, Classes and Sources of Waste WB 3ABR56330-V-2-P1, Classes and Sources of Waste Training Methods Discussion (0.7 hr) Performance (0.3 hr) Instructional Environment/Design Classroom (0.7 hr) Laboratory (0.3 hr) Group/Lockstep Instructional Guidance Discuss sources and classes of waste and the general characteristics of each.
3. Composition and Characteristics of Sewage a. Given incomplete definitions of terms or statements relative to characteristics and composition of sewage, complete the definition or statement with the proper term or information.	4.5 (3/1.5) Day 36 (3/1.5)	Column 1 Reference: 3a STS Reference: 11b Instructional Materials SG 3ABR56330-V-3, Composition and Characteristics of Sewage WB 3ABR56330-V-3-P1, Composition and Characteristics of Sewage Training Methods Discussion (2 hrs) Performance (1 hr) Outside Assignment (1.5 hrs)

PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
		Instructional Environment/Design Classroom (2 hrs) Laboratory (1 hr) Study Hall (1.5 hrs) Group/Lockstep **Instructional Guidance** Discuss characteristics and composition of sewage and the effects they have on sewage plant operation. Emphasize the hazards associated with sewage. Monitor student performance. Make and check outside assignments daily: On day 36, direct students to read pages 1 thru 25, SG V-1 thru 3, and answer questions on pages 2, 21, and 25.
4. Principles of Sewage Treatment a. Given a list of 20 statements and a list of 20 terms related to principles of sewage treatment, match the terms to the proper statements.	8 (6/2) Day 37 (6/2)	**Column 1 Reference** 4a — **STS Reference** 11c **Instructional Materials** SG 3ABR56330-V-4, Principles of Waste Treatment WB 3ABR56330-V-4-P1, Principles of Waste Treatment **Training Methods** Discussion (5 hrs) Performance (1 hr) Outside Assignment (2 hrs) **Instructional Environment/Design** Classroom (5 hrs) Laboratory (1 hr) Study Hall (2 hrs) Group/Lockstep

PLAN OF INSTRUCTION (Continued)

UNITS OF INSTRUCTION AND CRITERION OBJECTIVES 1	DURATION (HOURS) 2
5. Primary Waste Treatment with Field Trip	16 (12/4) Days 38 and 39
a. Observe operation of municipal sewage treatment plants during field trip and practice personal hygiene and safety during field trip.	(6/2)
b. Demonstrate a knowledge of operation of preliminary and primary treatment systems and components by making written responses to related questions.	(5/2)
c. Given the sewage treatment trainer and a schematic of a sewage plant, identify and operate the valves to perform the designated operations.	(1/0)

SUPPORT MATERIALS AND GUIDANCE 3

Instructional Guidance
Discuss principles of sewage treatment. Monitor student performance. Make and check outside assignments daily: On day 37, direct the students to read SG V-4, and answer questions on page 33.

Column 1 Reference	STS Reference
5a	11c, 11d
5b	11c, 11g(1), 11g(2), 11g(3), 11h(1), 11h(2), 11h(3), 11h(9), 11h(10), 11h(11),
5c	11h(1), 11h(2), 11h(9), 11h(10), 11h(11), 11m

Instructional Materials
SG 3ABR56330-V-5, Primary Waste Treatment
WB 3ABR56330-V-5-P1, Primary Waste Treatment

Audio Visual Aids
Slides, Sewage Plant Operation

Training Equipment
Sewage Treatment Trainer (12)

Training Methods
Field Trip (5 hrs)
Discussion (4 hrs)
Demonstration (1 hr)
Performance (2 hrs)
Outside Assignments (4 hrs)

PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
		Instructional Environment/Design Field Trip (5 hrs) Classroom (4 hrs) Laboratory (3 hrs) Study Hall (4 hrs) Group/Lockstep **Instructional Guidance** On day 38, brief students on safety and what to look for during field trip. The field trip will be for introduction and familiarization with waste treatment systems and equipment. Check students for compliance with personal hygiene requirements. After field trip, review what was observed. During day 39, discuss specific operation of preliminary and primary treatment and monitor student performance. Assignments: day 38, direct students to read SG V-5, pages 34-49. On day 39, direct students to read pages 50-65, and answer questions on pages 66 and 67.
6. Secondary Treatment with Field Trip	24 (18/6) Days 40, 41 and 42	**Column 1 Reference** — **STS Reference** 6a — 11c, 11h(2), 11h(4), 11h(5), 11h(6), 11h(7), 11h(8) 6b — 11c, 11h(4), 11h(5), 11i 6c — 11c, 11h(8), 11o 6d — 11c, 11h(8)
a. Following field trip to municipal and base sewage plants, list the types of systems and the treatment units at each plant.	(6/2)	
b. Given a list of incomplete statements and a list of terms or phrases relative to trickling filters and oxidation ponds, complete the statements with the proper terms or phrases.	(6/2)	**Instructional Materials** SG 3ABR56330-V-6, Secondary Treatment, Waste WB 3ABR56330-V-6-P1, Secondary Treatment, Waste WB 3ABR56330-V-6-P2, Configuration and Operation of Activated Sludge Systems WB 3ABR56330-V-6-P3, Principles and Configuration of Contact Aeration Systems

PLAN OF INSTRUCTION NO. 3ABR56330	DATE 6 June 1975	BLOCK NO. V	PAGE NO. 34

PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	DURATION (HOURS) 2	3 SUPPORT MATERIALS AND GUIDANCE
c. Using written definitions and schematic of an activated sludge plant, identify components relative to the plant and answer questions relative to operation of activated sludge plants.	(4/2)	Audio Visual Aids TVS 56-2, Sewage Plant Operation FLC 13-94, Municipal Sewage Treatment Process Training Methods Field Trip (5 hrs) Discussion (10 hrs) Performance (3 hrs) Outside Assignments (6 hrs) Instructional Environment/Design Field Trip (5 hrs) Classroom (10 hrs) Laboratory (3 hrs) Study Hall (6 hrs). Group/Lockstep Instructional Guidance Discuss systems, general operation and maintenance of units, and emphasize safety on field trip. Discuss details of operation in class and monitor student performance. Make and check outside assignments daily. On day 40, direct the students to read pages 68 thru 84 in SG V-6. On day 41, direct the students to read pages 85 thru 106. On day 42, review SG V-6.
d. Following written instructions, identify components and answer questions relative to operation of a contact aeration system.	(2/0)	
7. Tertiary Treatment	3 (2/1) Day 43	Column 1 Reference: 7a STS Reference: 11c
a. Given ten incomplete written statements relative to tertiary treatment, complete the statements with proper terms or information.	(2/1)	Instructional Materials SG 3ABR56330-V-7, Tertiary Treatment WB 3ABR56330-V-7-P1, Tertiary Treatment

PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
		Training Methods Discussion (1.5 hrs) Performance (0.5 hr) Outside Assignment (1 hr) **Instructional Environment/Design** Classroom (1.5 hrs) Laboratory (0.5 hr) Study Hall (1 hr) Group/Lockstep **Instructional Guidance** Discuss methods of tertiary treatment. Monitor student performance. Have students read pages 108 thru 114 of SG V-7 and answer questions on page 114 for outside assignment.
8. Chlorination and Stream Surveys	5 (4/1) Day 43	**Column 1 Reference** / **STS Reference** 8a / 11h(6) 8b / 11n
a. Given a schematic of a sewage plant, identify points where chlorine might be applied and answer written questions relative to sewage chlorination.	(2/0.5)	**Instructional Materials** SG 3ABR56330-V-8, Chlorination and Stream Surveys WB 3ABR56330-V-8-P1, Chlorination and Stream Surveys
b. From information provided, answer written questions relative to stream surveys.	(2/0.5)	**Training Methods** Discussion (2 hrs) Performance (2 hrs) Outside Assignment (1 hr)

PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
		Instructional Environment/Design Classroom (2 hrs) Laboratory (2 hrs) Study Hall (1 hr) Group/Lockstep **Instructional Guidance** Discuss principles of chlorination and monitor student performance. Have students read pages 115 thru 120 of SG V-8 and answer questions on pages 120 and 121 for outside assignment.
9. Industrial and Radioactive Wastes	8 (6/2) Day 44	**Column 1 Reference** — **STS Reference** 9a — 12a, 12b, 12c, 12d, 12e, 12f, 12l 9b — 7d(6), 7e(4), 12g, 12h, 12i, 12j, 12k
a. Using related information, identify types and dangers of industrial wastes, and methods of testing, treating, and disposing of them.	(3/1)	**Instructional Materials** SG 3ABR56330-V-9, Industrial and Radioactive Waste WB 3ABR56330-V-9-P1, Industrial Waste Treatment WB 3ABR56330-V-9-P2, Radioactive Waste Contamination
b. Using related information, identify radioactive markings, and state procedures for handling and disposing of radioactive materials.	(3/1)	**Training Methods** Discussion (4 hrs) Performance (2 hrs) Outside Assignment (2 hrs) **Instructional Environment/Design** Classroom (4 hrs) Laboratory (2 hrs) Study Hall (2 hrs)

PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
		Instructional Guidance Discuss types of industrial waste, dangers of untreated waste, tests for industrial waste, treatment methods and procedures, and maintenance of treatment equipment. Discuss the sources of hazards and identification of radioactive materials and areas. Discuss procedures for collecting, handling, and shipping radioactive waste. Monitor student performance. Make and check outside assignments daily: Day 44, read pages 122-130, SG V-9, and answer questions on pages 131 and 132.
10. Safety Practices	6 (4/2) Day 45	Column 1 Reference STS Reference 10a 7f(13) 10b 7a, 7f(13), 11d
a. Identify general safety information by completing measurable written items.	(2/1)	Instructional Materials SG AFS 54, 55, and 56, Safety All Courses WB 3ABR56330-V-10-P1, Safety Practices
b. Using AFR 127-101, Chapter 3, Section F, paragraph 3-23, identify sewage plant safety practices by listing two safety practices from each subparagraph a through i.	(2/1)	AFR 127-101, Chapter 3, Section F, Ground Accident Prevention Handbook Training Methods Discussion (2 hrs) Performance (2 hrs) Outside Assignment (2 hrs) Instructional Environment/Design Classroom (2 hrs) Laboratory (2 hrs) Study Hall (2 hrs) Group/Lockstep Instructional Guidance Discuss safety and safety publications. Monitor student performance. Make and check outside assignments daily: Day 45, read pages 1-15 in Safety SG and answer questions on pages 15 and 16.

PLAN OF INSTRUCTION (Continued)

UNITS OF INSTRUCTION AND CRITERION OBJECTIVES 1	DURATION (HOURS) 2	SUPPORT MATERIALS AND GUIDANCE 3
11. Measurement Test and Test Critique	**(2/0)** **Day 45**	

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LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE TCETC/17Jun75	INSTRUCTOR
COURSE NUMBER 3ABR56330	COURSE TITLE Environmental Support Specialist
BLOCK NUMBER V	BLOCK TITLE Waste Treatment and Disposal

LESSON TITLE
Field Sanitation (Day 36)

LESSON DURATION

CLASSROOM/LABORATORY	COMPLEMENTARY	TOTAL
2 Hrs	0.5 Hr	2.5 Hrs

POI REFERENCE

PAGE NUMBER	PAGE DATE	PARAGRAPH
30	6 June 75	1

STS/CTS REFERENCE

NUMBER	DATE
563X0	28 July 71

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
			SG V-1 WB V-1-P1 Slides, Field Sanitation

CRITERION OBJECTIVES AND TEACHING STEPS

1a. Following written instructions, demonstrate a knowledge of proper location, construction, operation, and maintenance of facilities for disposal of waste in isolated and combat areas by writing responses to measurable written items.

(1) Field latrines and urinals

(2) Cesspools and septic tanks

(3) Tile fields and subsurface sand filters

ATC FORM AUG 72 770

BODY (110 Min)

PRESENTATION:

1a. Following written instructions, demonstrate a knowledge of proper location, construction, operation, and maintenance of facilities for disposal of waste in isolated and combat areas by writing responses to measurable written items.

(1) Field latrines and urinals

(a) Types of latrines

1 Straddle trench-designed to accommodate 100 men per 16 feet total trench length or 8% of unit

a Trench dimensions- length 4 feet, width 1 foot, and depth 2½ feet

b Construction features- canvas walls, toilet paper holders, water for washing hands, covering dirt, drainage ditches.

c Maintenance-shelter and trench areas should be sprayed twice weekly with residual insecticide to control fly breeding.

d Operation-user of this type latrine straddles either end of trench in a squatting position, relieves himself, then covers his excreta with the covering dirt provided.

e Closing procedures-closing is accomplished when trench becomes filled to within one foot of the surface or when it is to be abandoned

Trenches, sidewalls, and grounds within 2 feet sprayed with residual insecticide

Fill trenches with 3 inch layers of dirt spraying with insecticide and packing each succesive layer

Mound trenches over with at least 1 foot of dirt.

Place sign reading-
CLOSED LATRINE and also the date.

2 Deep pit-designed for prolonged stay with standard type latrine box to accommodate 8% of any size unit at one time

a Pit dimensions-length 7½ feet, width 2 feet, depth 6 feet

b Construction features-excavate pit to accommodate standard latrine box

As a guide to pit depth, allow one foot per week of intended use if operated at full capacity

Not desirable for pit depth to exceed 6 feet

Pack dirt tightly around bottom of latrine box

Provide drainage ditch around latrine

c Maintenance-interior of latrine box is sprayed twice weekly with residual insecticide to control fly breeding d Operation-this type latrine designed to accommodate a 50 man unit of which 8% (4 people) can make use at one time.

e Closing procedures-same as for straddle trench.

3 Mound latrine-designed to be used where ground water or rock ledges are close to surface.

a Pit dimensions- length 7½ feet, width 2 feet, depth or height of mound dependent on depth of ground water.

b Construction features-plow area to aid liquid seepage

Dirt mound constructed in one foot layers with surface of each layer roughened and top of mound at least 6 feet wide and 12 feet long.

Desired height of mound and pit depth determined by water table.

c Maintenance-same as for deep pit

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d Operation-same as for deep pit

e Closing procedures-same as for straddle trench

4 Bored hole latrine-designed to accommodate one person at a time and is used at guard posts, lookout sites, or waiting stations in isolated or combat areas.

a Pit dimensions-hole drilled or bored 6 to 20 feet deep about 18 inches in diameter.

b Construction features-Drilled hole covered by a latrine box or metal drum with a flyproof seat cover and self-closing lid.

c Maintenance-same as for straddle trench.

d Operation-this type latrine designed for one man use.

e Closing procedures-same as for straddle trench.

5 Pail latrine-designed for use when dug latrine not possible.

a Pit dimensions-no pit provided; instead, a waterproof bucket is placed under a modified standard latrine.

b Construction-modified standard latrine box.

Leakproof bucket

Self-closing seats and rear doors

Flyproof latrine box

c Maintenance-pails emptied and cleaned daily or more often as neccessary.

Contents buried or burned

d Operation-designed to accommodate four men.

e Closing procedure-box, surrounding area, and pails are cleaned and disinfected with soap or residual HTH.

(b) Location of field latrines-field latrine facilities should not be located

1 Within 100 yards of mess facilities or water supplies

2 Where the slope, drainage, and depth of earth cover is inadequate

3 Within 30 yards of barracks or sleeping quarters

4 Upwind from mess facilities and quarters

(c) Urinal-An area specially designed for the discharge of urine

1 General rule-urinals should serve at least 5% of the unit's strength

2 Types of urinals

a Pipe urinal-consists of standard soakage pit with ventilating shaft and as many funnels as necessary to serve the given strength

Pit dimensions-length 4 feet, width 4 feet, depth 4 feet.

Construction features: 4x4x4 foot pit dug and filled with suitable contact material

Pit is topped with a 2 inch layer of small stones or gravel

Ventilating shaft sunk at each end of pit to reduce odor.

Pipes at least 1 inch diameter extending 30 inches above ground and at least 8 inches below surface

Pipe topped with tar paper or sheet metal funnel filled with grass or straw

Maintenance- change grass or straw filler daily

Wash funnel with soap and water

Operation-designed to serve 5% of unit strength

Closing procedures when soakage pit becomes clogged or site abandoned it should be:

Thoroughly sprayed with residual insecticide

Mounded over with a foot layer of compacted earth

Marked with sign reading CLOSED SOAKAGE PIT, dated

b Trough urinal-type of urinal using standard soakage pit with receptacle constructed above ground.

Pit dimensions-same as for pipe urinal

Construction features: trough should be 6 feet on a side

Have enough slope to carry liquids to discharge corner

Pipe connected to discharge corner to carry liquid into pit.

Filler of grass or
straw on a screen placed
at entrance to discharge
pipe.

Maintenance-change filler
daily

Burn or bury used filler

Wash trough daily

Operation-designed to
accommodate 5% of the
unit at one time

Closing procedure-same as
for pipe urinal

c Urinoil-type urinal-uses
standard soakage pit with
specially designed oil lined,
odor, and flyproof receptacle.

Pit dimensions-same as for
pipe urinal

Construction features: urine
receptacle constructed from a
55 gallon drum and pieces of
2-inch and 4-inch pipe welded
into place.

Remove top from one end
of drum.

Cut out 2 inch hole in
bottom center of other
end of drum

Insert 2 inch pipe into
hole approximately 6 to 8
inches allowing 6 to 12 inches
to extend below drum

Slotted, capped, 4 inch
pipe is placed over 2 inch
inside of drum so that the
highest slot is about 2 inches
below top of 2 inch pipe

Water is poured into the
drum to a level even with
the top of the 4-inch pipe.

A 2-inch layer of oil is
then poured on top of the
water

Maintenance-keep inside
walls of drum to a level
above oil line smeared
with an oily film to
prevent odors and fly
breeding

Operation-additional water
or urine added to drum
sinks below oil and is
flushed through the slots
in the 4 inch pipe and then
overflows into the soakage
pit

Closing procedures-remove drum

Follow same procedures as for pipe urinal

(2) Cesspools and septic tanks

(a) Construction features which characterize cesspools

1 Brick or masonary structures with dry open joints

2 Unlined bottoms

3 8 to 10 feet deep

(b) Explain the operation of a cesspool

(c) Desirable terrain for cesspool locations

1 Porous soil from 8 to 10 feet deep

2 Water table at least 15 feet deep

(d) Percolation test is used to determine leaching capability

(e) Sludge is removed from cesspools by

1 Bailing

2 Pumping

(f) Sludge is disposed of by burying

(g) Septic tanks are designed to hold sewage for a period of time to allow for bacterial action

(h) Operation of a septic tank is

1 Settling

2 Digestion

(i) The minimum size of a septic tank is 500 gallons

(j) Records kept on septic tank operation should include

1 Date of inspection

2 Conditions found

3 Corrective action taken

4 Sludge and scum depth

(3) Tile fields and subsurface sand filters

(a) Disposal tile fields may be used when sewage flow is small and porous soils exist

(b) Tile fields can be used when

1 Ground water table is well below the tile field

2 The soil has good leaching characteristics

3 Subsurface drainage is away from the tile field

4 Drainage area covers large area

(c) Minimum width of trenches based on types of soils are

1 Sand and sandy loam, 1 foot

2 Mixture of sand, loam and clay, 2 feet

3 Clay with some gravel, 3 feet

(d) Maximum trench depth is 2 feet

(e) Methods used to protect tile fields

1 Fencing

2 Posting

3 Seeding with grass

(f) Subsurface sand filters are used if soil is not absorbent

(g) Dosing tanks are used if distribution tile exceeds 200 feet

APPLICATION:

Have students accomplish WB 3ABR56330-V-1-P1

EVALUATION:

Evaluate by oral, written questions, and/or observation of student's performance during lesson. This may be accomplished at any time during lesson for increased effectiveness.

CONCLUSION (5 Min)

SUMMARY:

LESSON PLAN (Part I, General)

APPROVAL OFFICE TCETC/17Jun75	INSTRUCTOR
COURSE NUMBER 3ABR56330 /	COURSE TITLE Environmental Support Specialist
BLOCK NUMBER V	BLOCK TITLE Waste Treatment and Disposal

LESSON TITLE
Classes and Sources of Waste (Day 36)

LESSON DURATION

CLASSROOM/LABORATORY	COMPLEMENTARY	TOTAL
1 Hr	0	1 Hr

POI REFERENCE

PAGE NUMBER	PAGE DATE	PARAGRAPH
31	6 June 75	2

STS/CTS REFERENCE

NUMBER	DATE
563X0	28 July 71

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
None	None	None	SG V-2 WB V-2-P1

CRITERION OBJECTIVES AND TEACHING STEPS

2a. Given a list of ten waste materials, identify by written response a source of each and classify each as being domestic or industrial.

(1) Waste and pollution control

(2) Sources and characteristics of domestic wastes

(3) Sources and characteristics of industrial wastes

ATC FORM AUG 72 770

BODY (50 Min)

PRESENTATION:

2a. Given a list of ten waste materials, identify by written response a source of each and classify each as being domestic or industrial.

(1) Waste and pollution control

(a) Why controls are necessary

1 To regulate the amount and quality of waste or pollution discharged into public waterways

2 To insure public health

(b) Who implements these controls

1 Federal agency

2 State agency

3 Local agency

(2) Sources and characteristics of domestic wastes

  (a) Sources of domestic waste

    1 Homes

    2 Schools

    3 Businesses

  (b) Characteristics of fresh domestic waste

    1 Gray in color

    2 Soapy dishwater odor

    3 Contains dissolved, suspended, and/or floating solids

    4 pH normally 7

(3) Sources and characteristics of industrial wastes

(a) Sources of industrial wastewater

1 Aircraft washing

2 Fuel system maintenance

3 Paint stripping and corrosion control

4 Aircraft maintenance shops

5 Vehicle maintenance shops

6 Air materiel Depots

(b) Characteristics of industrial wastewater

1 Chemical odor

2 Color or dye

3 Oily or greasy

4 Toxic to living organisms 51

APPLICATION:

Have students complete WB-V-2-P1, Classes and Sources of Waste.

EVALUATION:

Evaluate by oral, written questions, and/or observation of student's performance during lesson. This may be accomplished at any time during lesson for increased effectiveness.

CONCLUSION (5 Min)

SUMMARY:

REMOTIVATION:

STUDY ASSIGNMENT: NONE

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE TCETC/17Jun75	INSTRUCTOR
COURSE NUMBER 3ABR56330	COURSE TITLE Environmental Support Specialist
BLOCK NUMBER V	BLOCK TITLE Waste Treatment and Disposal

LESSON TITLE
Composition and Characteristics of Sewage (Day 36)

LESSON DURATION

CLASSROOM/LABORATORY	COMPLEMENTARY	TOTAL
3 Hrs	1.5 Hrs	4.5 Hrs

POI REFERENCE

PAGE NUMBER	PAGE DATE	PARAGRAPH
31	6 June 75	3

STS/CTS REFERENCE

NUMBER	DATE
563X0	28 July 71

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
None	None	None	SG V-3 WB V-3-P1

CRITERION OBJECTIVES AND TEACHING STEPS

3a. Given incomplete definitions of terms or statements relative to characteristics and composition of sewage, complete the definition or statement with the proper term or information.

(1) Characteristics of sewage

(2) Composition of sewage

(3) Effects of characteristics and composition on plant operation

BODY (170 Min)

PRESENTATION:

3a. Given incomplete definitions of terms or statements relative to characteristics and composition of sewage, complete the definition or statement with the proper term or information.

(1) Characteristics of sewage

(a) Domestic sewage

1 Fresh domestic waste (sewage)-gray in color, odor of soapy dishwater

2 Stale or septic sewage-dark in color, rotten egg or decayed odor.

(b) Industrial waste

1 Color from dyes

2 Chemical odor

3 Oily film

(2) Composition of sewage

(a) Water 99.9%

(b) Solids 0.1%

(c) Solids are organic and inorganic

(d) Gases found in sewage are

1 Oxygen

2 Carbon dioxide

3 Hydrogen sulfide

4 Methane

(e) Volatile solids are found as a part of sewage waste

(f) Biological composition of sewage includes

1 Parasites

2 Saprophytes

3 Worms

(3) Effects of characteristics and composition on plant operation

(a) Factors affecting strength of sewage

1 Time of day

2 Rate of flow

3 Laundry and meat packing waste

4 Number of users

(b) Amount of grease in sewage

1 Grease retards biological action

2 Removed in primary clarifier by skimming

3 Placed in heated digester

4 Small amounts of grease may be digested

5 Large amounts of grease must be buried or burned

(c) Industrial waste

1 Normal dilution allows plants to handle industrial waste

2 Special holding tanks for large batch treatment sometimes used

3 Some chemicals can destroy bacterial action completely

APPLICATION:

Students will complete WB V-3-P1, Composition and Characteristics of Sewage.

EVALUATION:

Evaluate by oral, written questions and/or observation of student's performance during lesson. This may be accomplished at any time during lesson for increased effectiveness.

CONCLUSION (5 Min)

SUMMARY:

REMOTIVATION:

STUDY ASSIGNMENT:

SG 3ABR56330-V-4, Principles of Waste Treatment

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE	INSTRUCTOR
TCETC/17Jun75	
COURSE NUMBER	COURSE TITLE
3ABR56330	Environmental Support Specialist
BLOCK NUMBER	BLOCK TITLE
V	Waste Treatment and Disposal

LESSON TITLE

Principles of Sewage Treatment (Day 37)

LESSON DURATION

CLASSROOM/LABORATORY	COMPLEMENTARY	TOTAL
6 Hrs	2 Hrs	8 Hrs

POI REFERENCE

PAGE NUMBER	PAGE DATE	PARAGRAPH
32	6 June 75	4

STS/CTS REFERENCE

NUMBER	DATE
563X0	28 July 71

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
None	None	None	SG V-4 WB V-4-P1

CRITERION OBJECTIVES AND TEACHING STEPS

4a. Given a list of 20 statements and a list of 20 terms related to principles of sewage treatment, match the terms to the proper statements.

(1) Physical principles and processes used in sewage treatment

(2) Chemical processes used in sewage treatment

(3) Principles of biological processes used in sewage treatment

(4) Sewage treatment systems and subsystems

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BODY (340 Min)

PRESENTATION:

4a. Given a list of 20 statements and a list of 20 terms related to principles of sewage treatment, match the terms to the proper statements.

(1) Physical principles and processes used in sewage treatment

(a) Screening

(b) Sedimentation

(c) Filtering

(d) Evaporation

(e) Aeration

(f) Drying

(2) Chemical processes used in sewage treatment

  (a) Chlorine

  (b) Lime

  (c) pH adjustment

(3) Principles of biological processes used in sewage treatment

  (a) Aerobic

  (b) Anaerobic

(4) Sewage treatment systems and subsystems

  (a) Preliminary treatment

1 Bar screens

2 Grit chambers

3 Comminutors

(b) Primary

1 Imhoff tanks

2 Separate settling tanks

3 Separate digesters

4 Sludge drying beds

(c) Secondary

1 Trickling filters 62

- 2 Activated sludge
- 3 Contact aeration
- 4 Oxidation ponds

(d) Tertiary

- 1 Chemical coagulation
- 2 Filtration
- 3 Adsorption

(e) Preliminary equipment

- 1 Remove large floating objects

2 Removes abrasive material

3 Reduces size of large floating matter

(f) Bar screens

1 Prevent large suspended materials from entering the plant

2 Screenings from bar screen are disposed of by

a Grinding and returning to influent

b Incineration or sanitary landfill

c Burial, if other means are not available

(g) Grit chambers

1 Allow heavy inorganic solids to settle from sewage influent

2 Removes inorganic materials to prevent excessive wear on pumps and sludge removal equipment

3 Grit depth should be checked weekly

(h) Comminutors

1 A power driven grinder for shredding large solids

2 Installed at the influent of the plant, or at the pump station

3 It is a large vertical drum with knives attached for cutting

4 Used in conjunction with bar screens

(i) Parshall flumes: A device used to measure the rate-of-flow of sewage entering the plant

(j) Settling tanks: designed to detain sewage for a period of time to allow settleable solids to settle to bottom of tank

(k) Digesters: Allows for collected settled solids to digest to a more stable compound

(l) Drying beds: Dewaters sludge from digesters

(m) Secondary equipment: contact aeration, trickling filters, activated sludge and oxidation ponds. These are systems that promote a biological growth which decomposes solids left in effluent from primary systems

(n) Tertiary equipment: filters, adsorbs, or coagulates solids from effluent of secondary system

(o) Grease removal

  1 Preaeration: this is a method of agitating or stirring new sewage by diffusing air through it

    a Minute particles cling to the air bubbles and rise to the surface where they are skimmed off b This process also aids settling and reduces odors

c Side walls and troughs should be cleaned as needed

d Aeration is a continuous process

e Dissolved oxygen test is run on the effluent

2 Vacuum flotation operates on the same principle as aeration, with the addition of suction.

APPLICATION:

Have students complete WB 3ABR56330-V-4-P1, then point out the equipment on the trainer and have students distinguish between preliminary, primary, and secondary treatment and explain the operational steps of each.

EVALUATION:

Evaluate by oral, written questions, and/or observation of student's performance during lesson. This may be accomplished at any time during lesson for increased effectiveness.

CONCLUSION (10 Min)

SUMMARY:

REMOTIVATION:

STUDY ASSIGNMENT:

SW 3ABR56330-V-5, Primary Waste Treatment

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE TCETC/17Jun	INSTRUCTOR
COURSE NUMBER 3ABR56330	COURSE TITLE Environmental Support Specialist
BLOCK NUMBER V	BLOCK TITLE Waste Treatment and Disposal

LESSON TITLE
Primary Waste Treatment with Field Trip (Days 38 and 39)

LESSON DURATION

CLASSROOM/LABORATORY	COMPLEMENTARY	TOTAL
12 Hrs	4 Hrs	16 Hrs

POI REFERENCE

PAGE NUMBER	PAGE DATE	PARAGRAPH
33	6 June 75	5

STS/CTS REFERENCE

NUMBER	DATE
563X0	28 July 71

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
Sewage Treatment Trainer	None	None	SG V-5 WB V-5-P1 Slides, Sewage Plant Operation

CRITERION OBJECTIVES AND TEACHING STEPS

5a. Observe operation of municipal sewage treatment plants during field trip and practice personal hygiene and safety during field trips.

(1) Overview of what to look for on field trip

(2) Safety and personal hygiene

(3) Identification, function, and maintenance of plant and equipment

(4) Review of field trip

ATC FORM AUG 72 770

LESSON PLAN (Part I, General) CONTINUATION SHEET

CRITERION OBJECTIVES AND TEACHING STEPS (Continued)

5b. Demonstrate a knowledge of operation of preliminary and primary treatment systems and components by making written responses to related questions.

(1) Operation of grit removal devices

(2) Operation of screens and comminuting devices

(3) Preaeration and flotation

(4) Measuring devices

(5) Operation of settling tanks

(6) Operation of digesters and components

(7) Sludge disposal

5c. Given the sewage treatment trainer and a schematic of a sewage plant, identify and operate the valves to perform designated operations.

(1) Flow through comminutor, Imhoff tank, and secondary system

(2) Flow through bar screen, separate settling tank, and secondary system

(3) Drawing sludge to drying bed

(4) Recirculating sludge

Course No: 3ABR56330
Days 38 and 39

Branch Approval: Bobby Littlejohn
Date: 22 Jul 75

PART II

INTRODUCTION (10 Min)

CHECK PREVIOUS DAYS STUDY ASSIGNMENT

REVIEW:

ATTENTION:

OVERVIEW:

MOTIVATION:

CONCLUSION (DAY 38)

SUMMARY:

Briefly summarize the main points of the lesson

STUDY ASSIGNMENT:

Read SG-V-5 and answer questions on page 66

INTRODUCTION (DAY 39)

CHECK PREVIOUS DAYS STUDY ASSIGNMENT

REVIEW:

OVERVIEW:

MOTIVATION:

PRESENTATION:

5b. Demonstrate a knowledge of operation of preliminary and primary treatment systems and components by making written responses to related questions.

(1) Operation of grit removal devices

(a) Purpose

(b) Types

(c) Regulating flow

(d) Methods of removal

(e) Disposal of grit

(2) Operation of screens and comminuting devices

(a) Screens

1 Purpose

2 Construction

3 Cleaning

4 Disposal of screenings

(b) Comminutors

1 Purpose

2 Construction

(3) Preaeration and flotation

(a) Purpose

(b) Construction

(c) Operational procedure

(4) Measuring devices

(a) Purpose

(b) Weirs

(c) Parshall flume

(d) Parabolic flume

(e) Kennison nozzle

(f) Venturi meter

(g) Venturi flume

(h) Dosing cycle

(i) Timing pump operation

(5) Operation of settling tanks

(a) Primary settling tanks

1 Single purpose structures

2 Removes settleable solids

3 Classified as

a Hopper bottom

b Mechanical sludge collection

4 Mechanical sludge collectors must be operated continuously

(b) Imhoff tanks

1 Two compartments

  a Settling

  b Digestion

2 Upper tank slopes

3 The Imhoff tank includes:

  a Settling chamber

  b Sludge digestion chamber

  c Gas vent

  d Sludge pipe

  e Channel for flow reversal

4 Advantage of separating the settling and digestion processes

- a Settling is not hampered by rising gases
- b Keeps sewage fresh in settling compartment
- c Allows for more complete digestion

5 Imhoff tank operation

- a Flow reversal
- b Influent baffles distribute flow more equally
- c Surface scum is skimmed off
- d Sludge depth should be 2 ft. below settling compartment

  e Sludge withdrawal requirements

  f Characteristics of sludge

6 Prevent foaming

  a Excess raw solids

  b Excess sludge withdrawal

7 Tests performed on the settling compartment

  a Suspended solids

  b Settleable solids

  c pH

80

  d BOD

6 Tests performed on the digestion compartment

a pH

b Total solids

c Volatile solids

d Sludge depth

(6) Operation of digesters and components

(a) Decomposed sewage products

1 Gas

2 Supernatant liquor

3 Sludge

(b) Reduces volume of sludge

(c) Digestion of primary sludge occurs in three stages

- 1 Highly acid stage

- 2 Less acid stage

- 3 Fermentation (alkaline) stage

(d) Types of digesters

- 1 Liquid level (floating cover)

- 2 Gas holder cover

- 3 Fixed cover

- 4 Uncovered digester

(e) Digester operation

1 Pre-starting inspections

a Check pipes

b Check valves and stirring mechanism

c Check vacuum relief valve

2 Fixed cover digesters are completely filled with raw sewage

3 Floating covers are raised from the low level supports during initial filling

4 Seed digesters with partially or well digested sludge

5 Sludge being added to a digester should contain a high percentage of solids.

6 Pumping too much sludge into a digester will cause foaming

7 Supernatant may be treated by aeration, with or without lime

8 Supernatant is disposed of by

  a Returning to raw sewage equally divided between Primary settling tanks

  b Discharging it to sludge beds or lagoons when solids content is found higher than desirable

9 Heated digesters (85-95°F)

  a For internal heating, keep water in coils below 140°F b For external heating sludge is pumped through tubes in the unit, heated, and returned into the digester

10 Sludge circulation speeds up digestion by

a Mixing raw sludge and seed sludge

b Thickens the sludge

c Reduces its moisture

d Assists in maintaining alkaline conditions

e Releases gas

f Breaks up scum

11 Mechanical stirrer (agitator)

a Mixes contents

b Breaks up scum

c Keep grit removed from the floor of the tank

d Seeds incoming sludge

12 Scum and grease is readily digestible when kept wet and warm

(f) Drying beds

1 Sludge drying beds are used to dewater and dry digested sludge

2 Construction features of sludge drying beds are

a Ground is dug to desired depth and grade to form furrows

b Open tile drains are laid in the furrows

c Gravel, 6 to 12" is placed on top of tiles

d Sand, 6 to 12" is placed on top of gravel and leveled

e Outside walls are constructed of concrete, wood

3 Drying bed operation

a Sludge bed preparations are: removing sludge chunks; smoothing, cleaning and grading sand; placement of splash plates. Blowers are installed if the area is below ground. Sump pumps are also used to remove excess water

(7) Sludge disposal

(a) Purpose

1 Prevent disease

2 Allow room to treat additional sludge

(b) Dried sludge

1 Dry sludge may be used as fill in low areas

2 Dried sludge may be pulverized and used for fertilizer

3 Sludge should not be used on crops that will be eaten raw

(c) Wet sludge

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1 Wet sludge may be discharged directly from the digester to sludge lagoons in isolated areas

2 Wet sludge may also be disposed of by transporting it in tank boats for dumping at sea

(d) Sludge application

1 Application of 8 to 12" of sludge

2 Application of minimum depth if bed area is limited

3 Coagulation

(e) Removal of dried sludge

1 Remove sludge when it can be picked up with a fork without excessive sand sticking to the underside

2 Removed from beds by wheelbarrows, trucks or tractors

5c. Given the sewage treatment trainer and a schematic of a sewage plant, identify and operate the valves to perform designated operations.

(1) Flow through comminutor, Imhoff tank, and secondary system

(2) Flow through bar screen, separate settling tank, and secondary system

(3) Drawing sludge to drying bed

(4) Recirculating sludge

APPLICATION:

Students will use WB V-5-P1 to answer questions related to preliminary and primary treatment systems and to operate the sewage treatment trainer.

EVALUATION:

Evaluate by oral or written questions and/or observation of student's performance during lesson. This may be accomplished at any time during lesson for increased effectiveness.

CONCLUSION (10 Min)

SUMMARY:

REMOTIVATION:

STUDY ASSIGNMENT:

Read SG 3ABR56630-V-6

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE TCETC/17Jun75	INSTRUCTOR
COURSE NUMBER 3ABR56330	COURSE TITLE Environmental Support Specialist
BLOCK NUMBER V	BLOCK TITLE Waste Treatment and Disposal

LESSON TITLE
Secondary Treatment with Field Trip (Days 40, 41, and 42)

LESSON DURATION

CLASSROOM/LABORATORY	COMPLEMENTARY	TOTAL
18 Hrs	6 Hrs	24 Hrs

POI REFERENCE

PAGE NUMBER	PAGE DATE	PARAGRAPH
34	6 June 75	6

STS/CTS REFERENCE

NUMBER	DATE
563X0	28 July 71

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
None	None	None	SG V-6 WB V-6-P1 WB V-6-P2 WB V-6-P3 TVS 56-2 FLC 13-94

CRITERION OBJECTIVES AND TEACHING STEPS

6a. Following field trip to municipal and base sewage plants, list the types of systems and the treatment units at each plant.

(1) What to look for on field trip

(2) Safety

(3) Operation and maintenance of secondary sewage treatment

(4) Review of systems visited

LESSON PLAN (Part I, General) CONTINUATION SHEET

CRITERION OBJECTIVES AND TEACHING STEPS (Continued)

6b. Given a list of incomplete statements and a list of terms or phrases relative to trickling filters and oxidation ponds, complete the statements with the proper terms or phrases.

(1) Basic features of trickling filters

(2) Principles of filter operation

(3) Factors affecting filter operation

(4) Operational problems and controls

(5) Construction features of oxidation ponds and lagoons

(6) Principles of operation of oxidation ponds

6c. Using written definitions and schematic of an activated sludge plant, identify components relative to the plant and answer questions relative to operations of activated sludge plants.

(1) Components of a conventional activated sludge system

(2) Principles of activated sludge treatment

(3) Operation of a conventional activated sludge system

(4) Operation of a contact stabilization activated sludge system

(5) Operation of an extended aeration activated sludge system

6d. Following written instructions, identify components and answer questions relative to operation of a contact aeration system.

(1) Components of a contact aeration system

(2) Principles of operation of contact aeration

Course No: 3ABR56330
Days 40, 41, and 42

Branch Approval:
Date: 7 Aug 75

PART II

INTRODUCTION (20 Min)

CHECK PREVIOUS DAYS STUDY ASSIGNMENT

REVIEW:

ATTENTION:

OVERVIEW:

MOTIVATION:

BODY (1040 Min)

PRESENTATION:

6a. Following field trip to municipal and base sewage plants, list the types of systems and the treatment units at each plant.

(1) What to look for on field trip

(2) Safety

(3) Operation and maintenance of secondary sewage treatment

(4) Review of systems visited

APPLICATION:

Have students observe operation and maintenance, safety precautions and methods of treatment on the field trip.

Have students list the types of systems and the treatment units at each plant.

CONCLUSION (DAY 40)

SUMMARY:
Briefly summarize the main points of lesson.

STUDY ASSIGNMENT:
Read SG-V-6 and answer questions.

INTRODUCTION (DAY 41)

CHECK PREVIOUS DAYS STUDY ASSIGNMENT

REVIEW:

OVERVIEW:

MOTIVATION:

L

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PRESENTATION:

6b. Given a list of incomplete statements and a list of terms or phrases relative to trickling filters and oxidation ponds, complete the statements with the proper terms or phrases.

(1) Basic features of trickling filters

(a) Provides secondary treatment of sewage

(b) Basic structure

1 Filter media

2 Distributor

3 Underdrain system

(c) Filter media must be

1 3 to 8 feet deep

2 Hard and durable

97

3 Uniform in size

(d) Filters are classed according to rate of loading

1 Low rate

a Normal BOD loading of 600 lbs per acre foot

b Continuous or intermittent dosing

c Seasonal unloading of zoological film

d More complete BOD removal and nitrification

2 High rate

a Normal BOD loading of 3000 lbs per acre foot per day

b Continuous dosing

c More total BOD removal-
because of greater volume

d Less % BOD removal
from given volume of
sewage due to high rate
of flow

(2) Principles of filter operation

- (a) Aeration
- (b) Zoological film
- (c) Aerobic bacteria
- (d) Natural shedding of film
- (e) Removal of the shedded film

(3) Factors affecting filter operation

- (a) Rate of loading

- 1 Volumetric
- 2 BOD

(b) Uniformity of distribution

- 1 Fixed nozzles
- 2 Rotary distributor
- 3 Revolving disks

(c) Frequency of application

- 1 Intervals between dosing
- 2 During periods of low flow

(d) Ventilation

- 1 Path of air circulation
  - a Vents

b Underdrain

c Filter media pore spaces

2 Air circulation is accomplished by

a Natural circulation

b Forced circulation

(e) Seasonal temperature effects

1 Biological action is greater in summer

2 Natural air circulation depends on difference of air and sewage temperature

3 Air circulation is upward in winter and downward in summer

(4) Operational problems and controls

(a) Operational problems

  1 Ponding

  2 Filter flies

  3 Odors or septic film

  4 Freezing

(b) Operational controls

  1 Recirculation

  2 Chlorination

  3 Flooding

  4 Resting filter

(c) Operation of dosing siphon

1 Dosing siphons are used to supply sewage to subsurface filters and trickling filters intermittently

2 The main features of a dosing siphon include

a Siphon bell

b Auxiliary vent

c Blow-off trap

d Main trap

(5) Construction features of oxidation ponds and lagoons

(a) A shallow basin with a maximum depth of 5 ft.

(b) Sewage is discharged into the middle of pond

(6) Principles of operation of oxidation ponds

(a) Oxidation by natural process

(b) Oxygen is supplied by

  1 Absorption from the surface

  2 Vegetation and algae from the bottom

(c) Most efficient where evaporation and ground seepage is high

(d) Minimum prior treatment is primary settling

(e) Ponds are often used in series

(f) As the effluent passes from one lagoon to the next the pH increases and BOD decreases

(g) Alternately raise and lower the water level about 6" every 10 days for mosquito control

(h) A log is kept on the quality of effluent if overflowing

(i) A weekly test should be made of overflowing lagoons to include:

1 Quantity of overflow

2 Dissolved oxygen

3 pH

4 BOD

5 Suspended solids

6 Relative stability

APPLICATION:
Complete WB V-6-P1

CONCLUSION (DAY 41)

SUMMARY:

STUDY ASSIGNMENT:

Read SG-V-6, pages 85-107

INTRODUCTION (DAY 42)

CHECK PREVIOUS DAYS STUDY ASSIGNMENT

REVIEW:

OVERVIEW:

MOTIVATION:

PRESENTATION:

6c. Using written definitions and schematic of an activated sludge plant, identify components relative to the plant and answer questions relative to operation of activated sludge plants.

(1) Components of conventional activated sludge system

(a) Preliminary treatment equipment

(b) Primary settling tank

(c) Digester

(d) Sludge drying beds

(e) Aeration tanks

(f) Final settling tanks

(g) Aerators

(h) Sludge recirculating pumps

(2) Principles of activated sludge treatment

(a) The activated sludge process is the agitation of a mixture of sewage with bacterially active sludge

(b) Formation of dark-brown floc-sludge

(c) Sludge contains filamentous and unicellular bacteria and algae

(d) Presence of zoological-forming bacteria

(e) Supply of nutrients required

1 The aeration period for diffuser is 8 hours

2 The aeration period for mechanical aeration is 12 hours

(f) Five factors involved in purification of activated sludge are

1 Concentration of solids in the mixed liquor

2 Settling rate of mixed liquor solids

3 Volume of sludge return

4 Concentration of solids in return sludge

5 Quantity of air required for various loadings

(g) The characteristics of high-quality activated sludge are

1 Settles rapidly

2 Odorless

3 Golden brown

4 Granular

(h) The factors used in determining the quantity of activated sludge are

1 Mixed liquor solids

2 Sewage strength

3 Aeration time

4 Quantity of air

(i) Plant operation difficulties

1 Presence of oil and grease

2 Bulking of sludge

(j) The sludge index is useful in determining efficiency of the aeration system

(k) Perform the following steps necessary to arrive at a sludge index number

1 Sludge settles 20% volume per 30 minutes

2 Suspended solids are 1000 PPM (.1%)

3 Sludge index = $\frac{20\%}{0.1\%} = 200$

(4) Operation of a contact stabilization activated sludge system

(a) Modified activated sludge system

(b) Raw sewage aerated with activated sludge in contact mixer

(c) Reaerating settled sludge from clarifier to recycle

(5) Operation of an extended aeration activated sludge system

(a) Race track is one type

(b) Aeration 24-72 hours

(c) No reaeration of clarifier underflow

6d. Following written instructions, identify components and answer questions relative to operation of a contact aeration system.

(1) Components of a contact aeration system

(a) Preaeration tank

(b) Primary settling tank

(c) Digester

(d) Drying beds

(e) First stage aerator

(f) Intermediate settling tank

(g) Second stage aerator

(h) Final settling tank

(i) Chlorination (post if needed)

(2) Principles of operation of contact aeration

(a) Recirculation

1 Reduce primary settling odors

2 Seed incoming primary effluent

3 Maintain a higher DO content

(b) Constant blower operation

(c) Growth characteristics on plates

(d) Draw sludge from intermediate and final settling tanks at 4 hour intervals and return to plant influent

(e) Determine DO content during each shift

(f) Maintain dissolved oxygen content of 1 ppm from first stage aerator and 3 ppm from second stage aerator

APPLICATION:

Accomplish WB-V-6-P2 and P3 to identify components and answer questions

EVALUATION:

Evaluate by oral or written questions and/or observation of student's performance during lesson. This may be accomplished at any time during lesson for increased effectiveness.

CONCLUSION (20 Min)

SUMMARY:

REMOTIVATION:

STUDY ASSIGNMENT:

Read SC-V-7, Tertiary Treatment

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE TCETC/17Jun75	INSTRUCTOR
COURSE NUMBER 3ABR56330	COURSE TITLE Environmental Support Specialist
BLOCK NUMBER V	BLOCK TITLE Waste Treatment and Disposal

LESSON TITLE
Tertiary Treatment (Day 43)

LESSON DURATION

CLASSROOM/LABORATORY	COMPLEMENTARY	TOTAL
2 Hrs	1 Hr	3 Hrs

POI REFERENCE

PAGE NUMBER	PAGE DATE	PARAGRAPH
35	6 June 75	7

STS/CTS REFERENCE

NUMBER	DATE
563X0	28 July 71

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
None	None	None	SG V-7 WB V-7-P1

CRITERION OBJECTIVES AND TEACHING STEPS

7a. Given ten incomplete written statements relative to tertiary treatment, complete the statements with proper terms or information.

(1) Purpose and need for tertiary treatment

(2) Methods used for tertiary treatment

ATC FORM AUG 72 770

BODY (100 Min)

PRESENTATION:

7a. Given ten incomplete written statements relative to tertiary treatment, complete the statements with proper terms or information.

- (1) Purpose and need for tertiary treatment
    - (a) Further reduction of BOD
    - (b) Remove poisonous chemicals
    - (c) Remove nitrates and phosphates
- (2) Methods used for tertiary treatment
    - (a) Principles of tertiary treatment
        - 1 Adding a third step to primary and secondary

2 May be chemical or mechanical

(b) Equipment used

1 Chemical feeders

2 Chlorinators

3 Filters

4 Aerators

5 Newly designed equipment

a Reverse osmosis

b Ion exchangers

(c) Chemical treatment

1 Lime- used as a coagulant aid in removing impurities

2 Chlorine-a strong solution is used to oxidize poisonous metals

(d) Mechanical treatment

1 Effluent passes thru microscreens to remove micro-solids

2 Filtered through

a Anthrafilt

b Sand or gravel

c Activated carbon

3 Aeration

a Releases gases

b Oxidizes toxic metals

(e) Control measures

1 Tertiary effluent is lab tested for any remaining impurities

2 Constant observation necessary for efficient plant operation

3 Goal of tertiary treatment: Treated effluent exceeds quality of receiving stream

APPLICATION:

Students will complete statements in Workbook V-7-P1

EVALUATION:

Evaluate by oral or written questions and/or observation of student's performance during lesson. This may be accomplished at any time during lesson for increased effectiveness.

CONCLUSION (10 Min)

SUMMARY:

REMOTIVATION:

STUDY ASSIGNMENT:
NONE

Course No: 3ABR56330
Day 43

Branch Approval: Bobby Littlejohn
Date: 24 Jul 78

PART II

INTRODUCTION (10 Min)

CHECK PREVIOUS DAYS STUDY ASSIGNMENT

REVIEW:

ATTENTION:

OVERVIEW:

MOTIVATION:

BODY (100 Min)

PRESENTATION:

7a. Given ten incomplete written statements relative to tertiary treatment, complete the statements with proper terms or information.

(1) Purpose and need for tertiary treatment

(a) Further reduction of BOD

(b) Remove poisonous chemicals

(c) Remove nitrates and phosphates

(2) Methods used for tertiary treatment

(a) Principles of tertiary treatment

1 Adding a third step to primary and secondary

2 May be chemical or mechanical

(b) Equipment used

1 Chemical feeders

2 Chlorinators

3 Filters

4 Aerators

5 Newly designed equipment

a Reverse osmosis

b Ion exchangers

(c) Chemical treatment

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1 Lime- used as a coagulant aid in removing impurities

2 Chlorine-a strong solution is used to oxidize poisonous metals

(d) Mechanical treatment

1 Effluent passes thru microscreens to remove micro-solids

2 Filtered through

a Anthrafilt

b Sand or gravel

c Activated carbon

3 Aeration

a Releases gases

b Oxidizes toxic metals

(e) Control measures

1 Tertiary effluent is lab tested for any remaining impurities

2 Constant observation necessary for efficient plant operation

3 Goal of tertiary treatment: Treated effluent exceeds quality of receiving stream

APPLICATION:

Students will complete statements in Workbook V-7-P1

EVALUATION:

Evaluate by oral or written questions and/or observation of student's performance during lesson. This may be accomplished at any time during lesson for increased effectiveness.

CONCLUSION (10 Min)

SUMMARY:

REMOTIVATION:

STUDY ASSIGNMENT:
NONE

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE TCETC/17Jun75	INSTRUCTOR
COURSE NUMBER 3ABR56330	COURSE TITLE Environmental Support Specialist
BLOCK NUMBER V	BLOCK TITLE Waste Treatment and Disposal

LESSON TITLE
Chlorination and Stream Surveys (Day 43)

LESSON DURATION

CLASSROOM/LABORATORY	COMPLEMENTARY	TOTAL
4 Hrs	1 Hr	5 Hrs

POI REFERENCE

PAGE NUMBER	PAGE DATE	PARAGRAPH
36	6 June 75	8

STS/CTS REFERENCE

NUMBER	DATE
563X0	28 July 71

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
None	None	None	SG V-8 WB V-8-P1

CRITERION OBJECTIVES AND TEACHING STEPS

8a. Given a schematic of a sewage plant, identify points where chlorine might be applied and answer written questions relative to sewage chlorination.

(1) Prechlorination of sewage

(2) In plant chlorination

(3) Post chlorination

8b. From information provided, answer written questions relative to stream surveys.

(1) Purpose of stream surveys

(2) Sampling points

(3) Assets and liabilities of streams

(4) Reporting results of stream surveys

ATC FORM AUG 72 770

BODY (200 Min)

PRESENTATION:

8a. Given a schematic of a sewage plant, identify points where chlorine might be applied and answer written questions relative to sewage chlorination.

(1) Prechlorination of sewage

(a) Prechlorination is the addition of chlorine to the plant influent

1 Used during low flow of sewage

2 Keeps sewage fresh

3 Helps to prevent odors

(b) Forms of chlorine used

1 Gas (stored in liquid form)

2 Chloride of lime

3 Calcium hypochlorite

4 Sodium hypochlorite

(2) In plant chlorination

(a) Used in control of odors when prevailing winds are in the direction of inhabited areas

(b) For influent of trickling filters

(3) Post chlorination

(a) Reduces bacteria count

(b) Reduces BOD

8b. From information provided, answer written questions relative to stream surveys.

(1) Purpose of stream surveys

(a) Stream surveys are used to determine a stream's ability to receive waste without becoming polluted. The survey should also be considered when building a new sewage treatment plant or making additions to an old plant.

(b) Streams are tested weekly to determine:

1 Turbidity

2 Fish life

3 Algae and fungus growths

4 Sludge deposits

5 Vegetation on stream bottom

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6 Oil

7 Odor

8 Relative flow as being low, average, or high

(c) Stream analysis includes:

1 Dissolved oxygen (DO)

2 Biochemical oxygen demand (BOD)

3 Temperature

4 Bacteriological analysis, if sewage effluent is discharged above water supply intake

(2) Sampling points

(a) Above sewer outfall

(b) Below sewer outfall

(c) Several miles down-stream

(3) Assets and liabilities of streams

(a) Good and bad stream characteristics

1 BOD is liability (when high)

2 High concentration of DO is good

3 In warm water, decomposition is rapid, and oxygen is less soluble. (Summer is the critical season for stream protection)

(b) Sewage treatment procedures for correcting a polluted stream

1 Remove solids to prevent sludge deposits

2 Reduce BOD of plant effluent

3 Treat to aid nitrification

4 Re-aerate plant effluent

5 Chlorinate plant effluent

(4) Reporting results of stream survey

Records of stream surveys are kept on AF Form 1463, Sewage Utility Log (Supplementary)

APPLICATION:
Students will complete WB V-8-P1 by identifying on a schematic of sewage plant the points of chlorination and answer questions relative to stream survey.

EVALUATION:

Evaluate by oral or written questions and/or observation of student's performance during lesson. This may be accomplished at any time during lesson for increased effectiveness.

CONCLUSION (20 Min)

SUMMARY:

REMOTIVATION:

STUDY ASSIGNMENT:

Read SG V-9, Industrial Waste

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE TCETC/17 Jun 7	INSTRUCTOR
COURSE NUMBER 3ABR56330	COURSE TITLE Environmental Support Specialist
BLOCK NUMBER V	BLOCK TITLE Waste Treatment and Disposal

LESSON TITLE
Industrial and Radioactive Wastes (Day 44)

LESSON DURATION

CLASSROOM/LABORATORY	COMPLEMENTARY	TOTAL
6 Hrs	2 Hrs	8 Hrs

POI REFERENCE

PAGE NUMBER	PAGE DATE	PARAGRAPH
37	6 June 1975	9

STS/CTS REFERENCE

NUMBER	DATE
563X0	28 July 1971

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
None	None	None	SG V-9 WB V-9-P1 WB V-9-P2

CRITERION OBJECTIVES AND TEACHING STEPS

9a. Using related information, identify types and dangers of industrial wastes, and methods of testing, treating, and disposing of them.

(1) Types and sources of industrial wastes

(2) Hazards of untreated waste

(3) Industrial waste surveys and analyses

(4) Methods of treating industrial wastes

(5) Methods of disposing of industrial wastes

(6) Methods of testing

LESSON PLAN (Part I, General) CONTINUATION SHEET

CRITERION OBJECTIVES AND TEACHING STEPS (Continued)

9b. Using related information, identify radioactive markings, and state procedures for handling and disposing of radioactive materials.

(1) Sources of radioactive waste

(2) Measuring radioactivity

(3) Identification of radioactive markings

(4) Handling and disposing of radioactive waste

☆ GPO: 1972 779-386/24

BRANCH APPROVAL:
DATE: 29 Jul 1975

COURSE NO: 3ABR56330
DAY 44

PART II

INTRODUCTION (10 Min)

CHECK PREVIOUS DAYS STUDY ASSIGNMENT

REVIEW:

ATTENTION:

OVERVIEW:

MOTIVATION:

BODY (340 Min)

PRESENTATION:

9a. Using related information, identify types and dangers of industrial wastes and methods of testing, treating, and disposing of them.

(1) Types and sources of industrial wastes

(a) Types

1 Cyanides

2 Chromium compounds and other toxic metals

3 Acids and alkalies

4 Organic solvents, phenols, and aniline

5 Grease, oil emulsions, and detergents

6 Radioactive Waste

(b) Sources

1 Battery shop

2 Automotive cleaning

3 Vehicle repair

4 Paint shop

5 Plating shop

6 Airplane repair

7 Airplane cleaning

8 Laundry

(2) Hazards of Untreated Waste

(a) Fire and explosion

(b) Toxicity

(c) Interference with stream purification

(d) Odor, sight, and taste nuisances

(3) Industrial waste surveys and analyses

(a) Importance

(b) Flow measurement

(c) Sampling

(d) Analyses

(e) Effects of operating schedules

(f) Records

(4) Methods of treating industrial wastes

(a) General types of treatment

1 Physical

2 Biological

3 Chemical

4 Ion Exchange

(b) Treatment for specific waste

1 Cyanides

a sources-metal plating, steel hardening, rust prevention, and stain removal

b Dangers-a source of danger to potable water supply and in concentrations above 0.1 ppm, are capable of destroying fish life.

c Treatment-Lagooning or detention for 200 hours or more, chlorination with lime used to maintain pH above 8.5

2 Chromium compounds

- a Sources-chromic plating, bright dipping, copper stripping, anodizing, and metal plating.

- b Dangers-Toxic to anaerobic and aerobic bacteria. Also to fish life and mankind through the water we drink.

- c Treatment-Chromic acid recovery and reduction process

3 Acids and Alkalies

- a Sources- pickling and cleaning operations, corroded metal, and concrete sewer pipes.

- b Dangers-interferes with sludge digestion and biological action, toxic to fish, causes corrosion.

- c Treatment-Neutralization (The pH of industrial waste should be in a range of about 6.0 to 9.0 for admission to a sanitary sewer. Where both acid and alkali waste are involved,

the mixing of the two
may provide the required
pH correction.)

4 Organic solvents, Phenols, and Aniline

a source-Paint removal, cleaning of aircraft, powered ground equipment and research.

b Dangers-Create explosion and toxicity hazards, interfere with sewage treatment, and pollutes potable water.

c Treatment-chemical oxidation and biological oxidation

5 Greases, Oil emulsions, and Detergents

a Sources-cleaning of aircraft, powered ground equipment, motor pool, and laundry operations.

b Dangers-Coating of carrier systems and treatment units, increases, B.O.D., interferes with the efficiency of precipitants used used for sedimentation of industrial waste. Laundry waste usually carry pH values ranging from 9.0 to 10.8 releasing carbon dioxide which causes partial sludge flotation

c Treatment-physical and neutralization of pH

(5) Methods of disposing of industrial wastes

(a) Burning

(b) Burying

(c) Treatment of specific wastes

(6) Methods of Testing

(a) Colorimetric

(b) Electrometric

(c) Gravimetric

(d) Volumetric

(e) Sedimentation

9b. Using related information, identify radioactive markings and state procedures for handling and disposing of radioactive materials

(1) Sources of radioactive waste

(a) Hospital

(b) Electronic Equipment

(2) Measuring radioactivity

(3) Identification of radioactive markings

(a) Red symbols and letters on a yellow background or black symbols and letters on yellow background

(b) Green colors for electronics equipment.

(4) Handling and disposing of radioactive waste

(a) Handling procedures

(b) Precautions

(c) Radioactive liquid waste

(d) Radioactive solid waste

APPLICATION:

Using workbook, answer questions relative to industrial wastes treatment and disposal also answer questions on radioactive waste disposal.

EVALUATION:

Evaluate by oral or written questions and/or observation of students performance during lesson. This may be accomplished at any time during lesson for increased effectiveness.

CONCLUSION (10 Min)

SUMMARY:

REMOTIVATION:

STUDY ASSIGNMENT:

Read study guide on safety practices
SG AFS 54, 55, and 56, Safety All Courses

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE TCETC/17Jun75	INSTRUCTOR
COURSE NUMBER 3ABR56330	COURSE TITLE Environmental Support Specialist
BLOCK NUMBER V	BLOCK TITLE Waste Treatment and Disposal

LESSON TITLE
Safety Practices (Day 45)

LESSON DURATION

CLASSROOM	LABORATORY	TOTAL
4 Hrs	2 Hrs	6 Hrs

POI REFERENCE

PAGE NUMBER	PAGE DATE	PARAGRAPH
38	6 June 1975	10

STS/CTS REFERENCE

NUMBER	DATE
563X0	28 July 1971

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
None	None	None	SG AFS 54, 55, and 56 WB V-10-P1 AFR 127-101, Chapter 3, Section F

CRITERION OBJECTIVES AND TEACHING STEPS

10a. Identify general safety information by completing measurable written items.

(1) Causes of accidents

(2) Work area safety practices

(3) Fires and fire prevention

(4) Electrical hazards and safety practices

(5) Safety equipment

(6) First aid

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LESSON PLAN (Part I, General) CONTINUATION SHEET

CRITERION OBJECTIVES AND TEACHING STEPS (Continued)

10b. Using AFR 127-101, Chapter 3, Section F, paragraph 3-23, identify sewage plant safety practices by listing two safety practices from each subparagraph a through i.

(1) Physical hazards

(2) Sewage gas hazards

(3) Chemical hazards

(4) Safety equipment and devices

Course No: 3ABR56330
Day 45

Branch Approval:
Date: 7 Aug 75

PART II

INTRODUCTION (10 Min)

CHECK PREVIOUS DAYS STUDY ASSIGNMENT

REVIEW:

ATTENTION:

OVERVIEW:

MOTIVATION:

BODY (220 Min)

PRESENTATION:

10a. Identify general safety information by completing measurable written items.

(1) Causes of accidents

(a) Unsafe conditions

(b) Unsafe personal characteristics

(2) Work area safety practices

(a) Sewer maintenance safety

1 Remove and replace heavy manhole covers carefully and only with the proper tools

2 Wear an approved safety belt with attached lifeline, tested before each use, when entering deep sewers

(b) Pumping stations and treatment plants safety

1 Maintain a high level of good housekeeping, which involves cleanliness of floors, windows, walls, and equipment. Keep tools properly stored when not in use.

2 Keep walkways clean and free from slippery substances such as grease and oil

3 Take particular care with the electrical distribution system and facilities

4 Warning signs will be installed near dangerous machinery, or at locations involving a stumbling hazard

5 Sufficient fire extinguishers of types approved by the underwriters laboratories. They should be placed at readily accessible locations in the plant

(c) Machine guarding

1 For maximum safety, machines will be located to provide sufficient space for the operator to handle materials and perform routine job operations without interference from his own equipment or from other operators nearby

2 All machinery will be firmly secured to floor

3 Machines or their appropriate parts, will be color-painted according to established standards such as the TO 34 series and Chapter 4 of AFR 127-101, to increase contrast and improve visibility thereby reducing the accident potential.

4 All machines that are belt, chain or coupling driven will have safety guards

(d) Personal hygiene

1 Treat all cuts, skin abrasions, and similar injuries promptly

2 Call a doctor for all
but clearly minor injuries

3 Know first-aid procedures

4 Keep fingers out of nose,
mouth, and eyes

5 Be inoculated for water-
born diseases

6 After work, before eating,
and at other convenient
times, wash hands thoroughly
with soap and hot water

7 In laboratory work, use
siphon bulb when using
pipettes- not your mouth.

8 Keep hands out of sewage, sludge,
or other waste as much as possible

9 After handling waste,
wash hands before eating,
drinking or smoking

10 Keep finger nails
short and clean

11 Take a shower before you leave work

(3) Fires and fire prevention

(a) Chemical fire hazards

(b) Fire prevention principles

(4) Electrical hazards and safety practices

(a) Grounding

(b) Safety power switches

(c) Explosion proof motors

(5) Safety equipment

(a) When a hazard exists or is likely to exist, commanders will be authorized to direct exposed personnel to wear safety equipment and clothing

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(b) When job requirements specify the wearing of protective apparel and devices, this requirement then becomes both part of safety regulations and a condition of employment

(c) If a military person avoids or disregards orders to wear protective clothing or equipment required on a job, he may be guilty of failing to obey a direct order and will be subject to the provisions of the Uniform Code of Military Justice (UCMJ)

(d) Safety toe shoes

1. Safety toe shoes or approved foot or toe guards or both should be worn by personnel working in areas of heavy material handling

2. Safety toe shoes are issued to AF civilian employees world-wide by BEMO IAW TA 016

(e) Respiratory emergency equipment

1 Breathing equipment of the filter pad, canister, or cartridge type, is designed to reduce contaminated air to a safe level for breathing

2 Hose masks

3 Airline respirator

4 Self-contained oxygen breathing apparatus with bottle

5 Self-generating oxygen breathing apparatus

6 Gas mask

7 Respirator

8 Goggles for eye protection

(f) Safety hard hats

1 Hard plastic hats

2 Metal hats

(6) First aid

(a) Specific types of wounds

(b) Fractures and severe burns

(c) Heart Lung resuscitation

(d) Emergencies from toxic substances

(e) Prevention of adverse effects of heat

10b. Using AFR 127-101, Chapter 3, Section F, paragraph 3-23, identify sewage plant safety practices by listing two safety practices from each subparagraph a through i.

(1) Physical hazards

(a) Drowning

  - (b) Infection
  - (c) Asphyxiation
  - (d) Burns
  - (e) Electrocution
  - (f) Slipping, tripping, and falling
  - (g) General machinery injuries
- (2) Sewage gas hazards
  - (a) Hydrogen sulphide
  - (b) Methane gas
  - (c) Carbon dioxide
- (3) Chemical hazards
  - (a) Chlorine

(b) Acids and alkalies

(4) Safety equipment and devices

(a) Flame arresters

(b) Gas burners

(c) Good ventilation and lighting

APPLICATION:

Students will supply answers to complete Workbook V-10-P1

EVALUATION:

Evaluate by oral or written questions and/or observation of student's performance during lesson. This may be accomplished at any time during lesson for increased effectiveness.

CONCLUSION (10 Min)

SUMMARY:

REMOTIVATION:

STUDY ASSIGNMENT:

Read study guide SG 3ABR56330-VI-1
Extérnal Corrosion Control

STUDY GUIDES 3ABR56330-V-1 Thru 9

17-6

Department of Civil Engineering Training

Engineer Environmental Support Specialist

WASTE TREATMENT AND DISPOSAL

March 1972

SHEPPARD AIR FORCE BASE

Designed For ATC Course Use

DO NOT USE ON THE JOB

WASTE TREATMENT AND DISPOSAL

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This publication supersedes SGs 3ABR56330-V-1, 8 July 1970; 3ABR56330-V-2, 27 July 1970; 3ABR56330-V-3, 21 September 1970; 3ABR56330-V-4, 20 July 1970; 3ABR56330-V-5, 19 February 1971; 3ABR56330-V-6, 24 July 1970; 3ABR56330-V-7, 31 July 1970; 3ABR56330-V-8, 15 June 1970; 3ABR56330-V-9, 1 June 1970.

Dept of Civil Engineering Tng
Sheppard AFB, Texas

SG3ABR56330-V-1
6 March 1972

CLASSES AND SOURCES OF WASTE

OBJECTIVE:

This study guide will assist you in becoming familiar with the classes and sources of waste.

INTRODUCTION:

When you leave here you may be assigned to a base sewage plant. Your knowledge of classes and sources of sewage will help you become a better plant operator. The information to be covered will be under the following topics:

- CLASSES OF WASTE
- SOURCES OF WASTE

CLASSES OF WASTE

Domestic.

Domestic waste is liquid or semi-solid wastes from latrines, slop sinks, kitchens, showers and other sanitary conveniences. Storm run-off is not normally included in sanitary sewage. Although sewage contains considerable floating matter including fecal solids, paper, grease, and kitchen refuse, about 99.9% by weight of the total volume is water. Sewage generally has a higher temperature than the water supply. When fresh, it is usually gray and almost odorless; stale or septic sewage is dark and has a rotten or putrid smell. Ordinarily turbid, sanitary sewage becomes more septic as it grows older.

Industrial.

Industrial waste, usually liquids such as acids, oil and metal cleaning solutions, results from aircraft washing and industrial operations. When the volume of waste is small, it is normally disposed of through the sanitary sewage treatment plant. In some cases, however, it is necessary that separate industrial waste treatment plants be constructed.

SOURCES OF WASTE

Domestic Waste.

This type of sewage comes from all over the base area. It is from the kitchen and bath rooms in the base housing area. It also comes from the dining halls and troop living areas on the base. The other source is from the buildings on base with latrines. Most of the sewage being treated on Air Force Base will be of the domestic class.

Industrial Waste.

This type of waste will be from the motor pool, aircraft washing area, chemical and photo laboratories, garbage wash racks, laundries, dry cleaner, paint shops etc.

SUMMARY

In this study guide you have become familiar with the classes and sources of sewage. It is necessary that we have a safe, sanitary method of disposal. Some areas of a base will yield both classes of sewage.

QUESTIONS

1. What are the classes of sewage?
2. Domestic sewage comes from what specific place?
3. Industrial sewage comes from what specific place?
4. What percent of sewage by weight is water?
5. Describe the make-up of industrial waste?

REFERENCES

1. AFM 85-14, Maintenance and Operation of Sewage and Industrial Waste Plants and Systems
2. Water Supply and Sewage, by Ernest W. Steel, 4th edition.

FIELD SANITATION

OBJECTIVE

The purpose of this study guide is to assist you in learning field sanitation, its use, size, construction and operation of cesspools and septic tanks.

INTRODUCTION

In this study guide we will discuss the principles used to treat and dispose of small quantities of sewerage wastes. Such processes are normally used at small installations. These processes can be accomplished by means of cesspools, septic tanks, tile fields, and subsurface filters. The facilities are, for the most part, underground. The cesspool is adequate only for very small groups, such as those using a single building. Septic tanks are practical only for small installations. Both the effluent and sludge produced by such treatments are potentially offensive but, with careful design, construction, inspection and proper sludge removal, the facilities can be made to operate without nuisance and with minimum attention.

The methods for waste disposal will vary with the situation. At permanent and semipermanent camps, water-borne sewerage systems, like those of our cities, are provided. Under field conditions, military units must adopt various field methods to dispose of wastes.

These items will be discussed further under the following main topics:

--PROCEDURES FOR DISPOSAL OF WASTE IN ISOLATED AND COMBAT AREAS

--TYPES OF CONSTRUCTION AND INSTALLATION OF SOIL ABSORPTION SYSTEMS AND SEPTIC TANKS

PROCEDURES FOR DISPOSAL OF WASTE IN ISOLATED AND COMBAT AREAS

Of all types of sewage, human waste is the most frequent carrier of intestinal disease germs. Special precautions must be taken in its disposal. In many permanent and semipermanent installations human waste may be carried off by a water-borne sewage system. In temporary camps and isolated areas, field latrines are used by the individual units for the disposal of human waste.

Latrine Location

In isolated and combat areas, latrines are located at least 100 yards away from the unit kitchens and at least 100 feet away from any water supply source. Drainage of the waste into the soil must be away from the water source. Latrines should be dug in porous, well drained soil and should not extend below ground water level. A good latrine location is about 30 yards from the end of squadron streets within easy reach. It should be lighted at night unless military security demands concealment.

Latrine Construction

Latrines are used to bury excreta away from flies and to prevent fly breeding, soiling of the earth, and contamination of water supplies. Individual units are responsible for their maintenance. There should be enough latrine seats or spaces to accommodate eight percent of the unit at one time. Two linear feet are allowed for each man. Always construct the unit latrine away from the water supply to prevent contamination.

Latrines should be enclosed in temporary shelters such as tents, wall canvases, or brush screens. A drainage ditch is dug around the latrine enclosure to carry off surface water.

Hand washing facilities should be placed at the latrine exit. These may be made by running rods through two cans and supporting each rod on two forked stakes. See Figure 1. One can is filled with soapy water and the other with clear water.

Latrines

At temporary sites deep pit latrines and urinal troughs or soakage pits are used. Where tight soil conditions do not permit proper sewage disposal, a pail latrine may be necessary. However, until latrine facilities can be furnished, straddle trenches can be used.

STRADDLE TRENCH. A trench is dug 1 foot wide, 2½ feet deep, and 4 feet long. Two feet of length are allowed per man for at least eight percent of the unit. For 100 men, there would be four such 4 foot trenches as shown in Figure 2.

There are no seats in this type latrine. Boards can be placed along the sides of the trench to provide sure footing. When there is no natural concealment or isolation, a brush or canvas screen should be provided.

The earth removed while digging is piled at one or both ends of the trench. A paddle or shovel is placed in each pile so that every man can promptly cover the excreta and paper. This is done to reduce odors and keep flies away. Toilet paper rolls should be placed nearby on pegs or other holders and protected from rain by a wooden covering or tin can. A

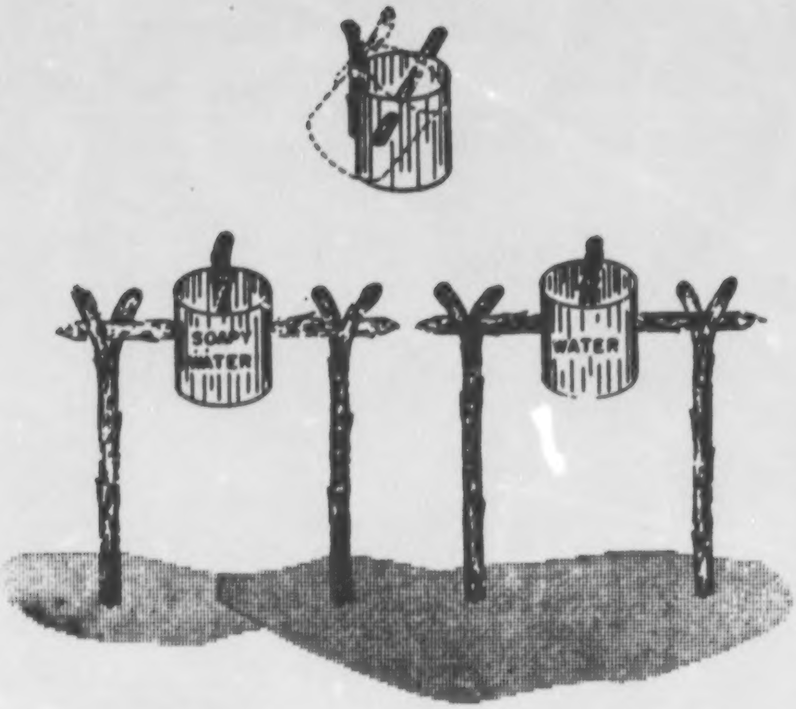
SOAPY WATER
WATER

Figure 1. Hand Washing Device

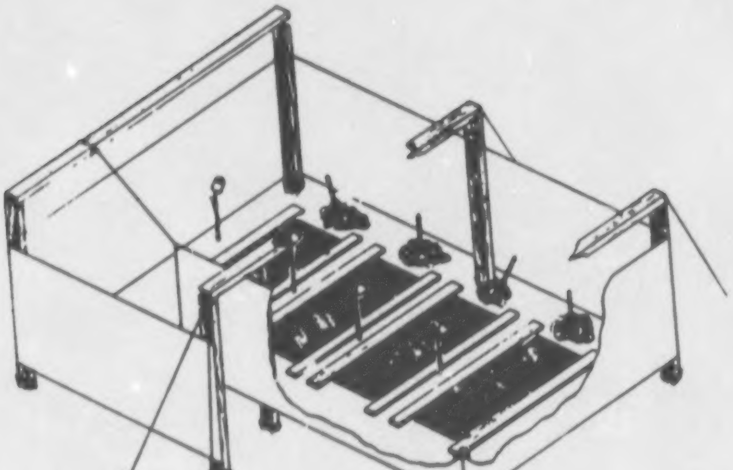

Figure 2. Straddle Trench Latrine for 100 Men

means of washing hands must be provided. If necessary a latrine orderly is assigned to make certain that excreta is covered and that there is enough toilet paper and sufficient water for men to wash their hands.

Straddle trench latrines are closed before they are abandoned or when they are filled to within one foot of ground level. Earth is domed over the pit and tightly packed. If the soil is loose or sandy, it should be mixed with oil. The site is then marked by a sign CLOSED LATRINE.

DEEP PIT LATRINE. This type of latrine is used with the standard latrine box and must conform to it in size. The standard box which takes care of four men is 8 feet long and 30 inches wide at the base. (A unit of 100 requires 16 feet of latrine space, 2 standard latrine boxes.) The four holes have flyproof covers. Blocks or bars installed to prevent the covers from opening to a vertical position will also insure self-closing after use. All cracks are made flyproof by nailing strips of wood or tin over them. The deep pit latrine is built with a urine trough or soakage pit. A metal deflecting strip is placed where it will keep urine from soaking into the wood. Then the whole unit is enclosed by brush or canvas, or a large wall tent. See Figures 3 and 4.

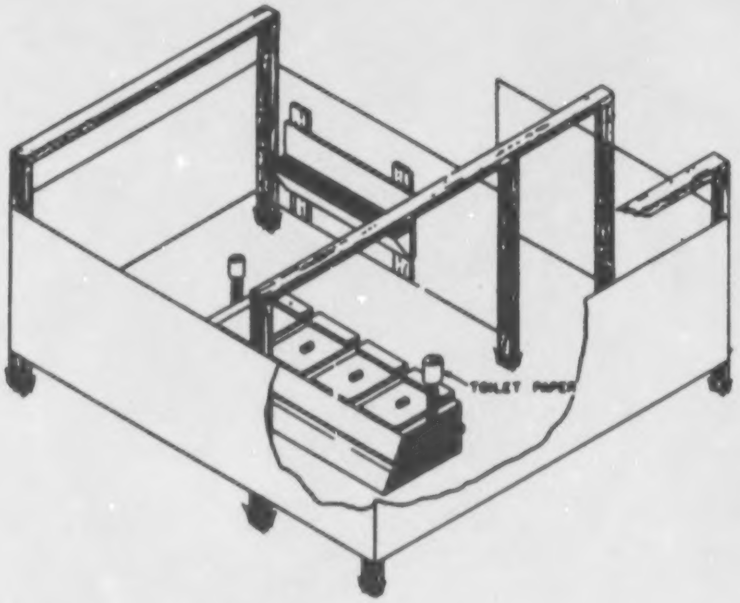

Figure 3. Deep Pit Latrine for 50 Men

The pit is dug 2 feet wide and 7½ feet long. This gives the latrine box 3 inches of support on all sides. The depth of the pit varies with the length of the time the latrine will be used. As a guide, allow 2 feet for

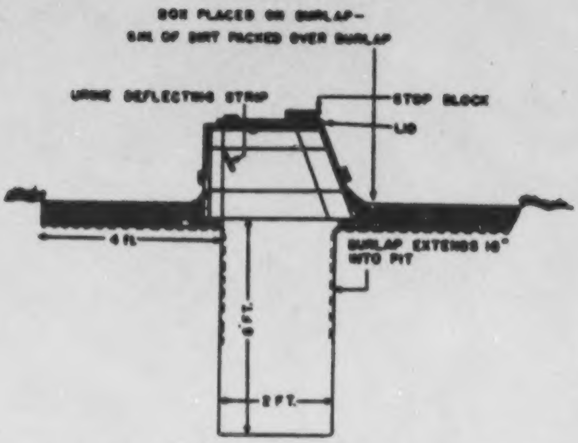

Figure 4. Cross Section of Standard Latrine Pit

cover and 1 foot additional for each week of use. (A latrine to be used 1 week will be dug 3 feet deep.) These measurements are for average soil. In clay or tight soil where absorption is poor, the depth should be increased in proportion. However, rock or high ground water levels may limit the depth in sandy soil. A support of planking or sandbags may be necessary to keep the sides of the pit from caving in. Drainage ditches are dug to lead rain water away from the pit.

Unless the latrine pit is in tight clay soil or has been blasted from rock, it has to be flyproofed in order to prevent fly breeding. This is done by digging around the pot an area 4 feet wide and 6 inches deep. The earth is then replaced over the area, tamped down, and more oil is added. If burlap is not available, oil is mixed with the earth alone which is tamped down. If there is no oil, use clay or other well compacted soil moistened with water. The latrine box is then carefully fitted over the pit and earth is packed tightly around the edges of the box to seal any remaining cracks. See Figure 5.

The only way to reduce odors and to prevent fly breeding is to keep the latrine clean, lid closed, cracks sealed, and make sure that the flyproofing seal is not broken. Putting lime or oil into pits is of little value. Burning out the latrine is of no value and will spoil the flyproofing. Once flies have entered, they can be prevented from breeding by using powder borax or other approved preparations. One pound of powder borax is used for every 8 hole latrine every 5 days. The powder should be distributed equally over the contents of the pit. If the contents are dry, add enough water to dissolve the borax but not enough to carry it away. If borax is not available, DDT or other insect sprays can be used. Care must be taken not to get the spray on top of the box or lids.

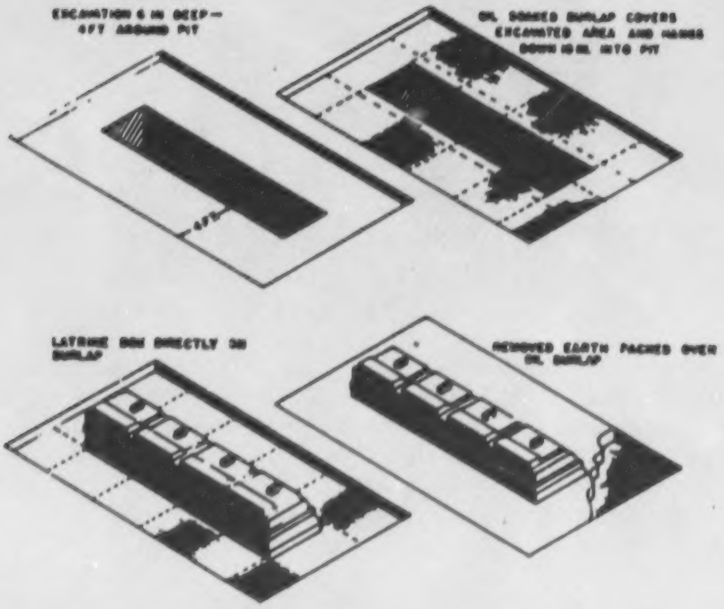
EXCAVATION 6 IN DEEP—
4FT AROUND PIT
OIL SOAKED BURLAP COVERS
EXCAVATED AREA AND HANGS
DOWN 10 IN. INTO PIT
4FT
LATRINE BOX DIRECTLY ON
BURLAP
REMOVED EARTH PACKED OVER
OIL BURLAP

Figure 5. Flyproofing Deep Pit Latrine

Latrines should be policed daily and kept clean at all times. There should always be enough toilet paper and water for hand washing. A holder should be provided with some type of covering to keep the paper dry. When flies are around, keep baited fly traps outside each latrine enclosure. The box itself and the seal at its earthen base should be kept tight and repaired. The seats should be scrubbed daily with soap and water and dried after cleaning. The seat cover should always be kept closed when not in use.

Deep pit latrines are closed when abandoned or when filled to within 2 feet of the surface of the pit. The box is removed, the pit is sprayed with an insecticide and covered with burlap when it is available. Next, it is filled with dirt (oil soaked if the soil is loose or sandy) and tamped and domed 12 to 18 inches above the surface. If hogs or dogs are in the vicinity, cover the pit with heavy stones, logs, brush, broken glass, etc., to keep them from unearthing the contents. The site should not be used again, so it is marked with a sign CLOSED LATRINE and the date of closing.

MOUND LATRINE. This type of latrine is used where there is a problem of ground water. The earthen mounds make it possible to construct a deeper pit.

A mound with a box 6 feet wide and 12 feet long (minimum) is built for a standard four-seat latrine box. It should be high enough to meet the pits requirements for depth, allowing one foot from the base of the pit to the ground water. First, the area where the mound is to be raised is plowed or dug up. Then layers of dirt are built up, each not more than a foot in depth. Each layer is packed solid and the surface is roughed before the next is added. If the earth is dry, sprinkling each layer will make it stick together and pack down more firmly. It may be necessary to use revetment or bracing to keep the walls of the pit from caving. The size of the base of the mound depends upon the kind of soil used. A relatively flat slope is preferred. Advice from a soil engineer and heavy equipment like bulldozers will speed up the work.

The mound latrine is flyproofed in the same way as the deep pit latrine. However, it will be necessary to extend the tamped area two feet down the slope of the mound in order to get 4 feet from the edge of the pit. Directions for closing the mound latrine are the same as for the deep pit latrine.

BORED-HOLE LATRINE. This type of latrine is used for sentry stations and other small isolated posts. It is a round hole, 1½ feet in diameter and 15 to 20 feet deep, covered by a one-hole box latrine or by an improvised seat such as an oil drum sunk into the ground with one end removed and the other end cut out to the shape of a standard latrine box seat hole fitted with a flyproof lid. A urinal consisting of 1 inch or larger pipe similar to that used in a urine soakage pit can be placed at one side of the seat. The lower end of the pipe extends into the hole, but must not protrude enough to be soiled by feces. Do not use the bored-hole latrine in shallow well areas or where high ground water level exists.

PAIL LATRINE. Where nonabsorbent or tight soil makes a deep pit latrine impracticable, a pail latrine is substituted.

A standard latrine box may be used as a pail latrine if hinged doors are placed on the rear, a floor added, and a pail placed under each seat. If the box is located in a building, it should be placed against the outside wall of the building so that the hinged doors of the latrine open directly on the outside. The latrine seats and rear doors should be self-closing and the box made flyproof. The floor of the box should be waterproof concrete if possible and should slope toward the rear enough for wash water to drain rapidly.

A trough urinal can be installed inside the latrine building with a drain pipe leading into a container outside the building.

Pails must be removed and emptied daily (more frequently if necessary). The contents of the pail may be disposed of in an Otway pit, by burial, or by incinerator, or if possible, into a nearby manhole or sewer. Empty pails are replaced in latrine containing at least one inch of disinfectant. At suitable intervals, pails are replaced by clean ones. See Figure 6.

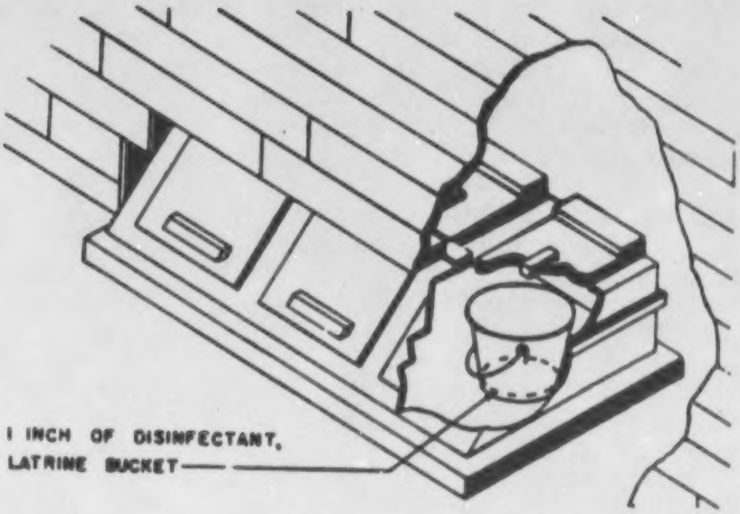

Figure 6. Pail Latrine in Building

Otway Pit

This pit is a type of septic tank used for dumping latrine pails or hospital bed pans. Disinfectant other than those in the latrine pails should not be used.

The pit is 10 feet long, 3 feet wide, and 6 to 8 feet deep. It should be located at least 100 yards from the kitchen, squadron streets, and water supply. The Otway pit is covered with timber on which is spread oil-soaked earth to make it flyproof and lightproof. A hole with flyproof and lightproof cover is left at one end of the roof into which excreta is dumped. There is another hole 6 inches in diameter at the other end of the roof over which a standard flytrap is fixed. The only way light enters the pit is through the hole under the flytrap; newly hatched flies making for the light are caught in this trap.

Urinals

TROUGH. If a deep pit latrine is dug in ground which absorbs liquids, a urine trough draining into the pit is included within the latrine enclosure. This trough may be built of tin, galvanized iron, or wood. If it is made of wood, it should be lined with tar paper. The trough is U- or V-shaped, 10 feet in length for every 100 men, and slopes to one end. At the lower end it is connected to the pit by a short section of pipe fitted with fine mesh fly screen. However, the pipe may be omitted and the trough may extend directly into the pit if the point at which it enters is flyproof. This trough must be washed daily with soap and water.

SOAKAGE PIT. If the latrine pit is in soil which absorbs liquids poorly, a separate urine soakage pit should be built. This pit is about four feet square and four feet deep. It is filled with pieces of broken rock, flattened tin cans, bricks, broken bottles, and other contact materials. See Figure 7.

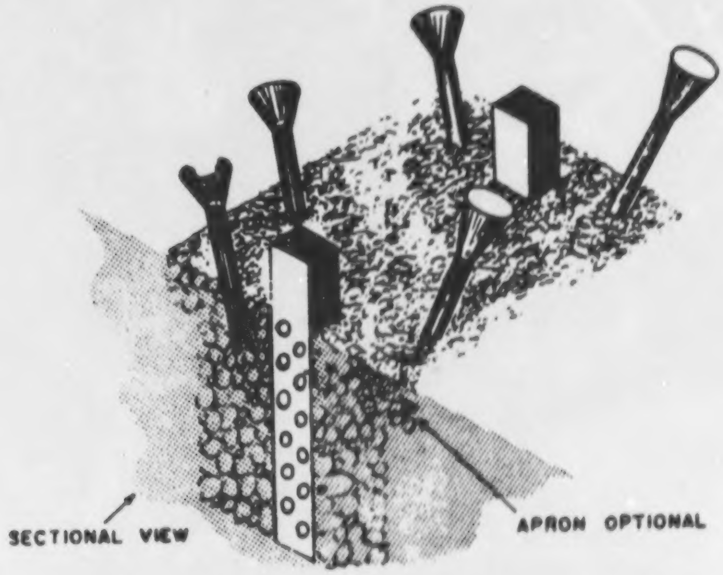

Figure 7. Soakage Pits with Pipe Urinals (With Ventilating Shafts)

Two ventilating shafts, 4 to 6 inches square are inserted to reduce odors. These shafts extend from about one foot above surface to within 6 inches of the bottom of the pit and contain a number of holes along the sides. The tops of the shafts are covered with fine screen, straw, or grass to keep out flies.

Urinals made of pipe, one inch in diameter or larger, are placed at each corner of the pit along the sides. (There should be at least 5 for every 100 men.) The pipes extend 8 inches below the surface. In the upper end of each pipe is placed a funnel of sheet metal, tar paper, or similar material. The rim of the funnel should be about 26 inches from the pipes to keep from getting clogged with cigarette butts, paper, etc. See Figure 7.

Since the soakage pit can usually accommodate 200 men indefinitely, it is better to surround it with a square trough urinal instead of using individual funnels. The trough is 6 feet square with a drain pipe extending from the lowermost corner to 8 inches below the surface in the center of the pit. See Figure 8. Care must be taken in leveling the trough to assure good drainage and to prevent pooling of urine. The pipe reaches below the surface to prevent contamination and to reduce odor. The urinal

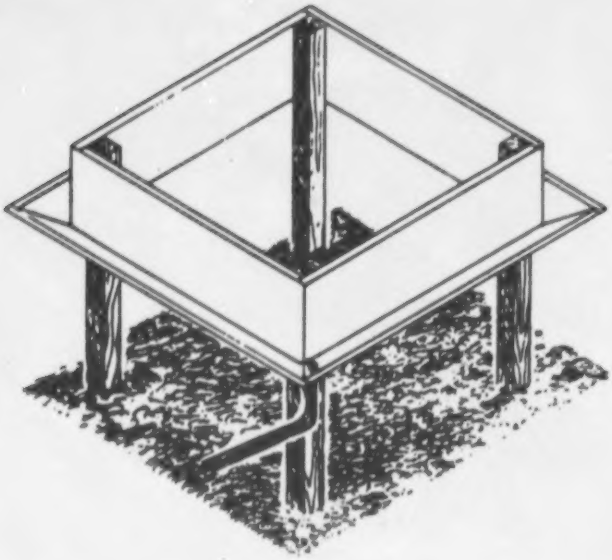

Figure 8. Soakage Pit with Trough Urinal (Without Ventilating Shafts)

trough may be located within the latrine enclosure with the pit outside.

Special precautions to take for urine soakage pits are:

1. Change the grass or straw in the funnels daily.
2. Clean the funnels with soap and water.
3. Change funnels when necessary.
4. Keep the pit free from oil or any other substance which might clog it.

When the pit is to be closed, withdraw the pipes and cover the pit with earth.

If the latrines are located out of the way, a large can or pail containing one inch of disinfectant can be placed at the end of each squadron street at night for use as a urinal. Each morning the contents of the cans will be poured into the latrines or urine soakage pits, and the cans washed thoroughly.

TYPES OF CONSTRUCTION AND INSTALLATION OF SOIL ABSORPTION SYSTEMS AND SEPTIC TANKS

Cesspools may be used for small quantities of sewage where soil conditions are exceptionally good and where clogging of the surrounding soil is not likely. A cesspool is a leaching well in which the walls are brick or masonry laid with dry open joints, and the bottom of the well is left unlined. Sewage flows into the cesspool and stands; solids settle to the bottom and are digested, grease and other floating materials float on the top, and liquids leach or seep into the soil.

When the soil is clogged and the unit is full, the solids must be removed by bailing or pumping. The solids should be buried where the water supply will not be endangered. Caustic potash (lye) will to some extent liquefy solids in a cesspool. However, chemical treatment is not recommended because it will not eliminate the necessity for removing the contents when the cesspool is full and clogged. When clogging continues and cannot be corrected by solids removal, the best solution would be to install a septic tank system with a tile disposal field. See Figure 9. Leaching Cesspool with Wood Cover.

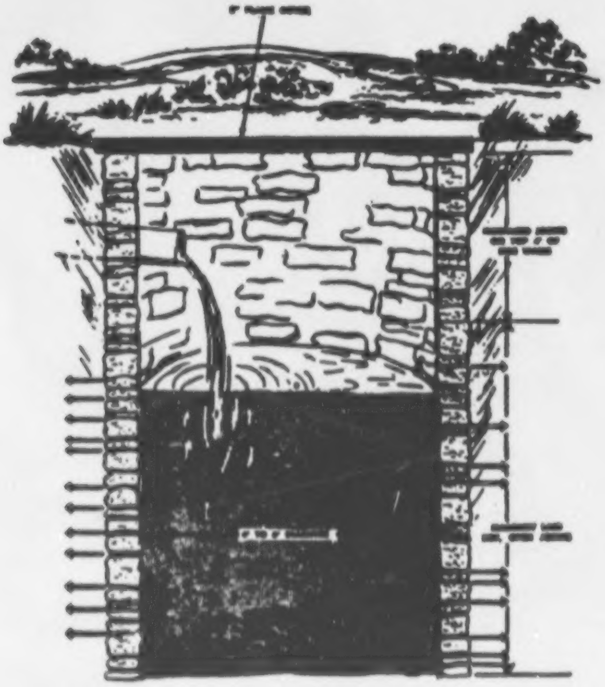

Figure 9. Leaching Cesspool with Wood Cover

Location

Since the action of a cesspool depends upon its seepage or leaching into the surrounding soil, it should be used only where the soil is porous to a depth of at least eight (8) to ten (10) feet. To protect water sources, the ground water table should normally be below this elevation. In fine sand areas, leaching into the soil is improved by putting gravel around the walls and on the bottom.

Additions

A second cesspool may be constructed when the first becomes filled to take the overflow from the first. In such cases, the first should operate as a septic tank to collect the settling and floating solids and to provide a trapped outlet on the connection leading to the next leaching cesspool. Septic tanks may be placed advantageously ahead of leaching cesspools in large installations to reduce the quantity of solids passing to the cesspools well, thereby delaying clogging and loss of leaching effect. Additional leaching cesspools should be separated from existing cesspools by a minimum of 20 feet measured between outer walls of wells.

Size

Total number and size of cesspools required depends on quantity of sewage and leaching characteristics of the total exterior percolating area above the ground water table including bottoms and side walls below the maximum flow lines. The allowable rate of sewage application per square foot per day based on the recommended leaching test is given below. Soils requiring more than 30 minutes for a fall of 1 inch are unsatisfactory for leaching, and some other disposal method should be used.

Time for Water to Fall One Inch (Minutes)	Allowable Rate of Sewage Application in Gallons Per Square Foot of Leaching Area
1	5.3
2	4.3
5	3.2
10	2.3
30	1.1

Test

The test for leaching should be made by digging a pit about one-half the proposed depth of the cesspool with a test hole 1 foot square and 18 inches deep in the bottom. The test hole is filled with water to a depth of 6 inches which is allowed to drain off. Water 6 inches deep is again added, and the downward rate of percolation measured in minutes required for the water surface to lower 1 inch in the hole.

When cesspools are properly maintained, maintenance will be at a minimum. Solids accumulating in a cesspool must be removed periodically and transported to a safe place for burial. To avoid clogging and overflowing, cesspools should be inspected semiannually to determine need for scum and sludge removal and correcting deficiencies.

SEPTIC TANKS

Septic tanks do not require continuous operation and may be used at very small scattered installations where sewage with floating and settleable solids removed can be disposed of by dilution (discharge into a body of water), leaching wells or trenches, subsurface tile fields, or artificial subsurface filter systems. Septic tanks when installed and maintained properly provide an efficient sanitary method of sewage disposal.

Size

The size of the septic tank is determined by the amount of sewage to be disposed of. The minimum size for septic tanks is 500 gallons. Small tanks should have sufficient capacity to detain or hold sewage for at least 24 hours at the average daily rate of flow, plus 25 percent of the daily flow added for sludge storage space. One of the most important factors in determining the size of a septic tank is the number of people to be served. It can be designed to serve a small group of people in a single building or up to the largest size where about 500 people can be served. Septic tanks serving large populations (approaching 300 or over) should have capacity for not less than 12 hours detention plus an extra capacity of 15 to 25 percent of the daily flow for sludge space.

Operation

Septic tanks are simple in operation. Sewage flows into a tight (non-leaching) tank and is detained there long enough for large solids to settle out. Solid matter settles to the bottom of the tank and partially decomposes producing liquids and gases. Slow undisturbed flow through the septic tank provides for the separation of liquids and sludge and for bacterial action. The bacteria acting upon the sludge are anaerobic. They work only in the dark and where there is little or no air. Undigested solids form a residue of sludge on the tank bottom. From 40 to 60 percent of the incoming suspended solids are carried off suspended in the effluent. The tank inlet and outlet can be submerged to insure a reduced flow. Wooden baffle boards can be used for this purpose. A submerged outlet prevents scum which forms on top of the surface from passing out the effluent. The effluent is the sewage waste or liquid discharged from the outlet.

Inspection

Periodic inspection is necessary to prevent health hazards and nuisance. Inspections should be performed at periods of high flow and as frequently as required by tank size and population load, but at least every six months to determine that:

1. Tank inlet and outlet are free from clogging; accumulated material should be immediately removed and disposed of by burying.

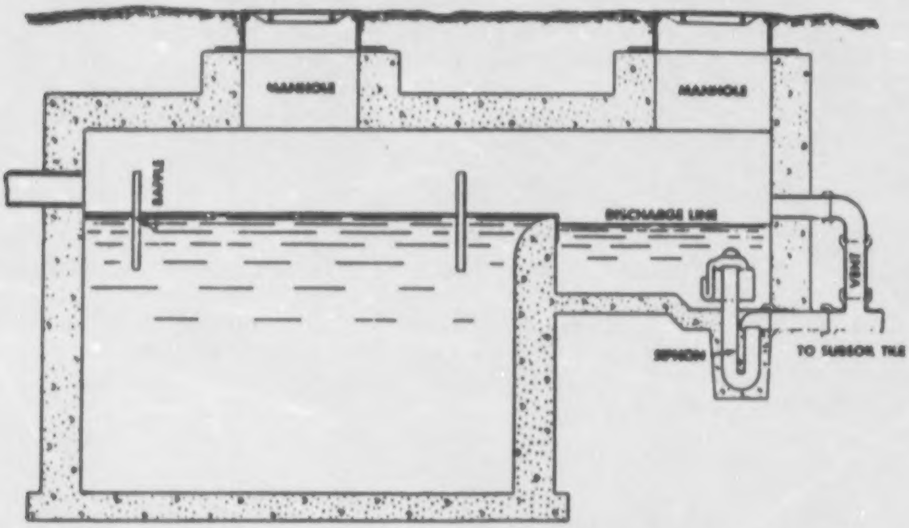

Figure 10. Septic Tank with Dosing Siphon

2. Depth of scum is such that scum is not passing out with the effluent, and sludge and scum accumulation does not exceed one-fourth of tank capacity.

3. Effluent passing to subsurface disposal is relatively free from suspended solids to avoid clogging of subsurface pipelines and filter beds. The quantity can be determined by the Imhoff Cone Test; more than one milliliter of settleable solids per liter of effluent should be considered excessive.

4. Appurtenant facilities such as dosing siphons, distribution boxes, and tile fields are working properly.

Separating sludge and scum from the liquid in septic tanks is difficult; for small tanks they are customarily mixed, the entire contents being removed when cleaning. The material removed contains fresh or partially digested sewage solids which must be disposed of without endangering public health. Disposal through manholes in the nearest sewerage system as approved by local authorities or burial in shallow furrows on open land is recommended. A diaphragm type sludge pump is best suited for removing the tank contents which should be transported in a watertight closed container.

Contents and effluents of septic tanks are characteristically odorous and offensive. Addition of lime, chlorine, or any other chemicals or proprietary compounds, is of questionable value and is not recommended. The most effective means of keeping tanks working properly is through periodic removal of sludge and scum.

Records

Records should be kept of each septic tank and disposal field inspection. These should include date of inspection, sludge and scum depth, conditions found, and corrective action taken.

Disposal Tile Field

Where small quantities of sewage (less than 2000 gallons per day) are involved and favorable soil conditions exist, settled sewage may be discharged into the ground through subsurface tile fields. Effluent from small septic tanks installation is usually disposed of in this manner.

PROPER FUNCTIONING. Tile fields consisting of lines of cement or clay tile in the ground with open joints are used for disposal of settled sewage into the ground. A fiber pipe, with holes bored in the lower portion to allow drainage, may be used for these drain lines. The following conditions are important for proper functioning of tile fields:

1. The ground water table is well below the level of the tile field.
2. The soil has satisfactory leaching characteristics within a few feet of the surface and extends several feet below the tile.
3. The subsurface drainage is away from the field.
4. The area is adequate.
5. There is no possibility of polluting drinking water supplies, particularly from shallow dug or driven wells in the vicinity.

TEST. Length of the tile and details of the filter trench generally depend upon the character of the soil. Soil leaching tests should be made at the site as described for leaching cesspools, except that the test hole should extend only to the approximate depth at which the tile lines are to be laid. For extensive tile fields, several tests to determine the best location and average condition should be made. From test results, the rate of sewage application to the total bottom area of the tiled trenches may be taken from the following table. Soil testing over 30 minutes is not suitable.

FROST LINE. Placing tile below the frost line to prevent freezing is not necessary. Tile placed 18 inches below the ground operated successfully in New England for many years. Subsurface tile should never be laid below ground water level.

PIPE SIZE. Design and construction should provide for handling and storage of some solid material, eliminating as much as practicable the opportunity for clogging near pipe joints. Pipe 4 to 6 inches in diameter is recommended. The larger pipe gives greater storage capacity for solids and larger area at the joint for solids to escape into the surrounding gravel.

Time for Water to Fall One Inch (Minutes)	Allowable Rate of Sewage Application in Gallons Per Square Foot Per Day of Leaching Area
1	4.0
2	3.2
5	2.4
10	1.7
30	.8

PIPE LAYING. To provide for free discharge of solids from the line to the filter trench, the pipe must be laid with 3/8 inch clear openings. The top of the space is covered with tar paper or similar material to prevent entry of gravel. Bell and spigot pipe is easily laid to true line and grade. Good practice calls for breaking away 2/3 along the bottom of the bells at the joint and using small wood block spacers. The pipe is commonly laid at a slope of about 0.5 foot per 100 feet when taking the discharge directly from the septic tank and 0.3 foot per 100 feet when a dosing tank is used ahead of the field.

TRENCH WIDTHS. Minimum widths of trenches on the basis of soils are as follows:

1. Sand and sandy loam, 1 foot.
2. Loam, sand, and clay mixture, 2 feet.
3. Clay with some gravel, 3 feet.
4. Trenches should preferably be not over 2 feet deep.

LAYOUT. The layout of the piping system depends on the shape of the available area and the slope of the surface. A typical layout is shown in Figure 11. When tile is laid in sloping ground, flow must be divided equally to each lateral. Because of the small slope required for distribution lines and the advantage of having a fairly uniform depth of cover soil, individual lateral trenches follow the ground contour lines as shown in Figure 12. Tile fields are generally laid out in a herringbone pattern or with laterals at right angles to the main distributor. The distance between laterals should be not less than three (3) times the width of the trench. A distribution box at the head of the disposal field to which the laterals are connected will insure equal distribution of flow.

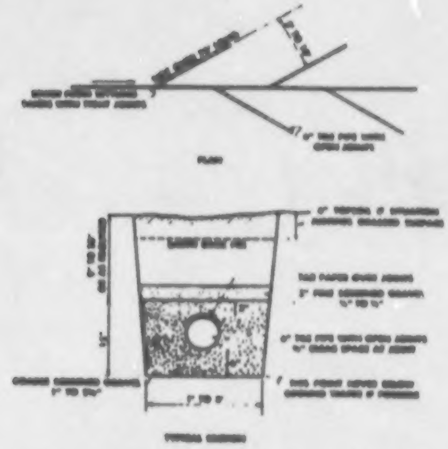

Figure 11. Typical Layout of Subsurface Tile System

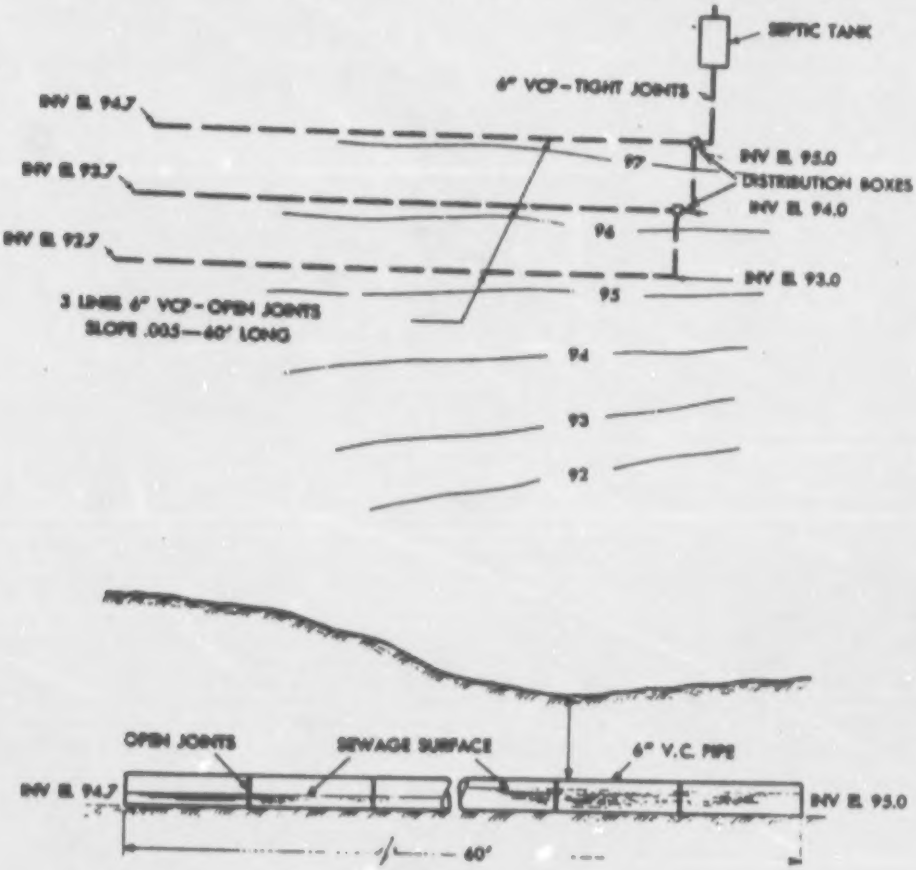
SEPTIC TANK
6" VCP–TIGHT JOINTS
INV EL 94.7
INV EL 95.0
97
DISTRIBUTION BOXES
INV EL 93.7
INV EL 94.0
96
INV EL 92.7
INV EL 93.0
95
3 LINES 6" VCP–OPEN JOINTS
SLOPE .005—60' LONG
94
93
92
OPEN JOINTS
SEWAGE SURFACE
6" V.C. PIPE
INV EL 94.7
INV EL 95.0
60'

Figure 12. Layout of Tile Field on Sloping Ground

BEDS. The tile is laid on a bed of screened coarse gravel 6 inches deep with 3 inches of coarse gravel around and over the pipe. Coarse screened stone passing a 2½ inch mesh and retained on a 3/4 inch mesh is recommended. This gravel bed gives a relatively large percentage of voids into which the solids may pass and collect before the effective leaching area becomes seriously clogged. The soil which fills the trench must not fill the voids in the coarse screened gravel around the pipe. A 3-inch layer of medium screened gravel over the coarse stone and 3 inches of either fine screened gravel of suitable bankrun gravel over the medium stone is recommended.

PROTECTING THE FIELD. Once a tile field is constructed, all traffic must be excluded by fencing or posting to prevent crushing the tile. Planting shrubs or trees over the field is not good practice since the roots tend to clog the tile lines; grass over the lines assists in removing the moisture and keeping the soil open.

INSPECTION. Inspections of the field distribution boxes should be made at frequent intervals. If any portion of the tile field is not taking its share of effluent, appropriate adjustments should be made. If it appears that the tile line may be clogged or if effluent is coming to the tile field

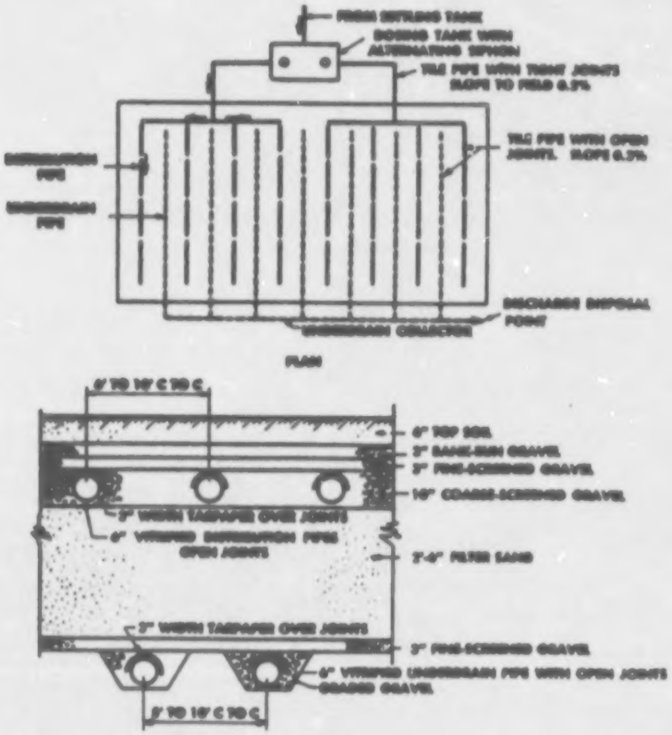
FROM SETTLING TANK
DOSING TANK WITH ALTERNATING SIPHON
T&C PIPE WITH TIGHT JOINTS SLOPE TO FIELD 0.3%
T&C PIPE WITH OPEN JOINTS. SLOPE 0.3%
DISTRIBUTION PIPE
UNDERDRAIN PIPE
DISCHARGE DISPOSAL POINT
UNDERDRAIN COLLECTOR
PLAN
6' TO 10' C TO C
6" TOP SOIL
3" BANK-RUN GRAVEL
3" FINE-SCREENED GRAVEL
10" COARSE-SCREENED GRAVEL
3" WIDTH TARPAPER OVER JOINTS
6" VITRIFIED DISTRIBUTION PIPE OPEN JOINTS
2'-6" FILTER SAND
3" WIDTH TARPAPER OVER JOINTS
3" FINE-SCREENED GRAVEL
6" VITRIFIED UNDERDRAIN PIPE WITH OPEN JOINTS
GRADED GRAVEL
5' TO 10' C TO C

Figure 13. Plan and Section of Subsurface Sand Filter Bed

ground surface, the lines should be excavated to determine the reason for failure or clogging. Necessary corrective action should be taken.

Subsurface Filters

USE AND SIZE. If the soil will not absorb sewage sufficiently for the use of subsurface tile fields, subsurface sand filters may be required; open sand filters are preferred if they can be placed in an isolated area. Subsurface sand filters are used only when no isolated area is available. Sand filters should not be used where septic tank discharges exceed 2000 gallons per day. These filters are individual trenches or rectangular beds consisting of distribution tile, filter medium, effluent collecting underdrain tile, and discharge line.

SUMMARY

To improve living conditions and prevent disease, human waste must be disposed of in a sanitary manner. In field maneuvers, combat, and isolated areas, this is done through the construction of latrines and soakage pit urinals.

There are a number of different types of latrines and soakage pits. Some of these are: straddle trenches, deep pit latrines, mound latrines, pail latrines, Otway pits, urine soakage pits, and urine troughs. Special precautions must be taken in order to maintain the latrines and pits in a sanitary condition.

At semi-permanent and permanent installations sewage must be disposed of in a manner acceptable to sanitary requirements. Primary and secondary treatments are used followed by chlorination, aeration, and disposal. Smaller installations use septic tanks and subsurface irrigation.

QUESTIONS

1. In what type soil is cesspools best suitable?
2. How are solids removed from cesspools when they become full?
3. What is the best method for correcting a cesspool when clogging continues and cannot be corrected by removal of solids?
4. When a second cesspool is added, what is the minimum distance that the second cesspool can be constructed?
5. How are solids disposed of from cesspools?
6. What is the difference between cesspools and septic tanks?
7. What is the minimum size for septic tanks?

8. What percent of suspended solids are removed in a septic tank?

9. List 5 conditions important for proper functioning of tile fields.

10. What size tile pipe is recommended and why?

11. If the soil will not absorb the sewage effluent with the use of tile fields, what can be installed?

12. What is the purpose of dosing tanks?

13. Latrines are located at least how many yards from kitchens? From any water supply source?

14. What percent of a unit should be provided latrine facilities?

15. Name 5 types of field type latrines.

16. What is the primary purpose of the Otway pit?

17. What are the dimensions for a straddle trench?

18. How are latrines marked after they are full or the unit moves to a new location?

19. How deep is the disinfectant in a pail for the pail type latrine?

20. Give the general description for constructing a urinal soakage pit.

COMPOSITION AND CHARACTERISTICS OF SEWAGE

OBJECTIVES

The purpose of this study guide is to assist you in becoming familiar with the composition and characteristics of sewage.

INTRODUCTION

Sewage is made up of various types of waste from different areas, and may come from a base or a city. These different types of waste are classified as either domestic sewage or industrial sewage. The information concering the effects of the two classes of sewage on plant operation and the composition of the two classes will be presented under the following headings:

- EFFECTS OF SEWAGE ON PLANT OPERATION
- COMPOSITION OF SEWAGE

This study guide may not include all the information you need to know; therefore, the study of additional material is recommended.

EFFECTS OF SEWAGE ON PLANT OPERATION

Domestic and industrial sewage have similar effects on plant operation. These effects include the clogging of pumps, coating of equipment with grease, reducing flow, blocking flow, creating offensive odors, increasing the biochemical oxygen demand, and raising or lowering the pH. One important difference between the effects of domestic and industrial waste is that industrial waste may kill the helpful bacteria when it enters a domestic waste plant in large quantities.

COMPOSITION OF SEWAGE

The general term sewage is used to describe all waste materials flowing through the sanitary sewage system. It is largely the water supply of a base after it has been fouled by many uses.

Sanitary Sewage

Sanitary sewage, which is better known as domestic sewage, is the liquid or semiliquid waste from latrines, slop sinks, kitchens, showers, and other sanitary conveniences. Although sewage contains considerable floating matter, including fecal solids, paper, grease, and kitchen refuse, about 99.9% (by weight) of the total flow is water. Sewage normally has a higher temperature than the water supply. When sewage is fresh, it is usually gray in color and almost odorless. When sewage is stale or septic, it is dark in color and has a rotten or putrid odor.

Industrial Waste

Industrial waste consists of liquids such as acids, oils and metal treatment solutions which are the result of aircraft washing and industrial operations. Normally, small amounts of industrial waste can be disposed of through the sanitary sewage treatment plant. However, it is necessary that separate industrial treatment plants be constructed to dispose of large amounts of industrial waste.

Composition of Sewage

Materials frequently contained in sewage are grouped under the following headings:

1. Liquids
    a. Oil
    b. Soaps
    c. Acids
    d. Alkalies
    e. Gasoline
    f. Kerosene
    g. Milk
    h. Alcohol
    i. Solvents
2. Organic Matter
    a. Sticks
    b. Paper
    c. Leaves
    d. Cotton products
    e. Food stuff
    f. Fecal matter
    g. Small animals
    h. Plastic products
3. Inorganic Matter
    a. Rocks
    b. Gravel
    c. Sand
    d. Metal products

SUMMARY

Sewage is made up of various types of waste from different areas. This waste is classified as either domestic or industrial. Domestic waste consists of waste from latrines, slop sinks, kitchens, showers and other sanitary conveniences. Industrial waste consists of acids, oils and metal-treating solutions. Industrial waste may kill helpful bacteria when it is disposed of through the domestic waste treatment plant. Sanitary or domestic sewage is usually gray in color and odorless. About 99.9% by weight of the total sewage flow is water. Sewage is made up of liquid, organic and inorganic materials.

QUESTIONS

1. How will domestic sewage affect plant operation?
2. Name four sources of domestic sewage.
3. How does the temperature of sewage compare with that of the water supply?
4. Name three organic materials.
5. Name three inorganic materials.
6. In what way would large quantities of industrial waste affect a domestic treatment plant?
7. What percent by weight is water in the total sewage flow?
8. What is the color of fresh sewage?

REFERENCES

AFM 85-14, Maintenance & Operation of Sewage and Industrial Waste Plants and Systems

PRINCIPLES OF WASTE TREATMENT

OBJECTIVE

The purpose of this study guide is to aid you in learning how to process sewage.

INTRODUCTION

When you graduate from this course you will be going to a base and perhaps be operating a waste treatment plant. You will understand the equipment in the plant if you know the principles on which it operates. The principles will be discussed under the following topics:

- TREATMENT PRINCIPLES
- EQUIPMENT USED
- STAGES OF TREATMENT

This study guide may not contain all information you need to know; therefore, the study of additional material is recommended.

TREATMENT PRINCIPLES

Physical

Sewage usually contains a quantity of undigestible inorganic or mineral matter such as sand, gravel, glass, metal, and even some large organic matter that must be removed. The removing or grinding or shreeding of this matter is referred to as a physical principle. Sludge drying beds are also considered a physical treatment since evaporation takes place, and no chemical or biological process takes place. Grease removal is also a physical treatment. It can therefore be understood that any treatment the sewage receives other than chemical or biological can be referred to as physical treatment.

Chemical

The use of chemicals in sewage is limited. Chlorine may be used for odor control but it must be added continuously and is very expensive. It is more feasible to add an application of copper sulfate every six months during peak flow. Lime and iron salts may also be used but these only control rather than prevent odor. A dose of 5 ppm of copper sulfate is used when the chemical is in contact with the organisms for an extended period. It is recommended that a dose of 50 ppm be used in the sewers because of the short contact period. Copper sulfate is added in the uppermost manholes during or just before peak flow. Hydrated lime is also used in slurry form to control acid digestion. Sufficient lime should be added when the pH of the sludge is below 6.5. Enough should be added to raise the pH to 7.0. Chlorine is also used during low flow to keep sewage fresh. The plant effluent is also chlorinated in order to prevent disease.

Chlorine can also be used during low flow in order to prevent filter flies. An application of hydrated lime to sludge during withdrawal helps reduce odors and fly breeding on the drying beds.

Biological

Biochemical Oxygen Demand (B.O.D.) organic matter in sewage, chiefly of human or food origin, is unstable and changes readily under the effects of chemical and biological (bacterial) action. As this organic matter decomposes, it uses up the oxygen originally present and additional oxygen must be supplied to prevent it from becoming stale and putrid. The quantity of oxygen utilized by microorganisms in the oxidation of the organic matter, enabling sewage to form stable compounds is called the biochemical oxygen demand. It is measured in parts per million (ppm). Satisfaction of this demand depends on time and temperature, and B.O.D. tests of sewage are normally run at a standard temperature of 20°C for a five day period. B.O.D. indicates the amount of decomposable organic matter present and, therefore, the concentration or strength of sewage. Weak sewage has a B.O.D. of about 100 ppm; medium sewage, 200 ppm; and strong sewage, 300 ppm.

Bacteria in sewage are of three types: aerobes, which live and develop in the presence of free oxygen; anaerobes, which live and develop in the absence of oxygen; and facultative bacteria, which are active under either condition. Almost all sewage bacteria feed on organic matter, and their feeding activities aid in the process of decomposition. Some types of bacteria are pathogenic, or disease-bearing; these usually originate in body wastes discharged by victims or carriers of infectious diseases such as typhoid, dysentery, and cholera. The bacteria decompose or break down the sewage solids into different compounds as a result of their feeding activity. Fresh sewage contains enough free oxygen to support the aerobic bacteria on the organic matter for a time. The products of this are stable and free from unpleasant odors. As the oxygen diminishes the anerobic bacteria become active, causing unstable and odorous products. This is called putrefaction. An adequate supply of oxygen must then be introduced to favor aerobic activity and promote decomposition without nuisance. This final step is called oxidation.

EQUIPMENT USED

Bar Screens

These are used to protect pumps and remove floating materials that would form a heavy floatage in settling tanks. They are made of steel bars spaced 1/2 inch or more apart. The bars form a grid that is placed at an angle in the direction of flow in the influent channel. They are cleaned manually or mechanically. In manual cleaning, the screen chamber is flushed frequently with a heavy stream of water to remove grease and material collected in front of and under the screen. A long-handled rake is used to pull the screenings to the top of the screen and deposit them on a draining platform. The mechanically cleaned screen has a built-in rake. It either operates by a float switch which activates the rake when there is a loss of head or pressure through the screen, or by an electric motor with gear reducers.

Five screens with 1/4-inch openings or smaller are sometimes used to remove an additional quantity of suspended solids before further treatment. They are commonly of the rotating drum or rotating disk type. Cleaning is accomplished by scrubbing or

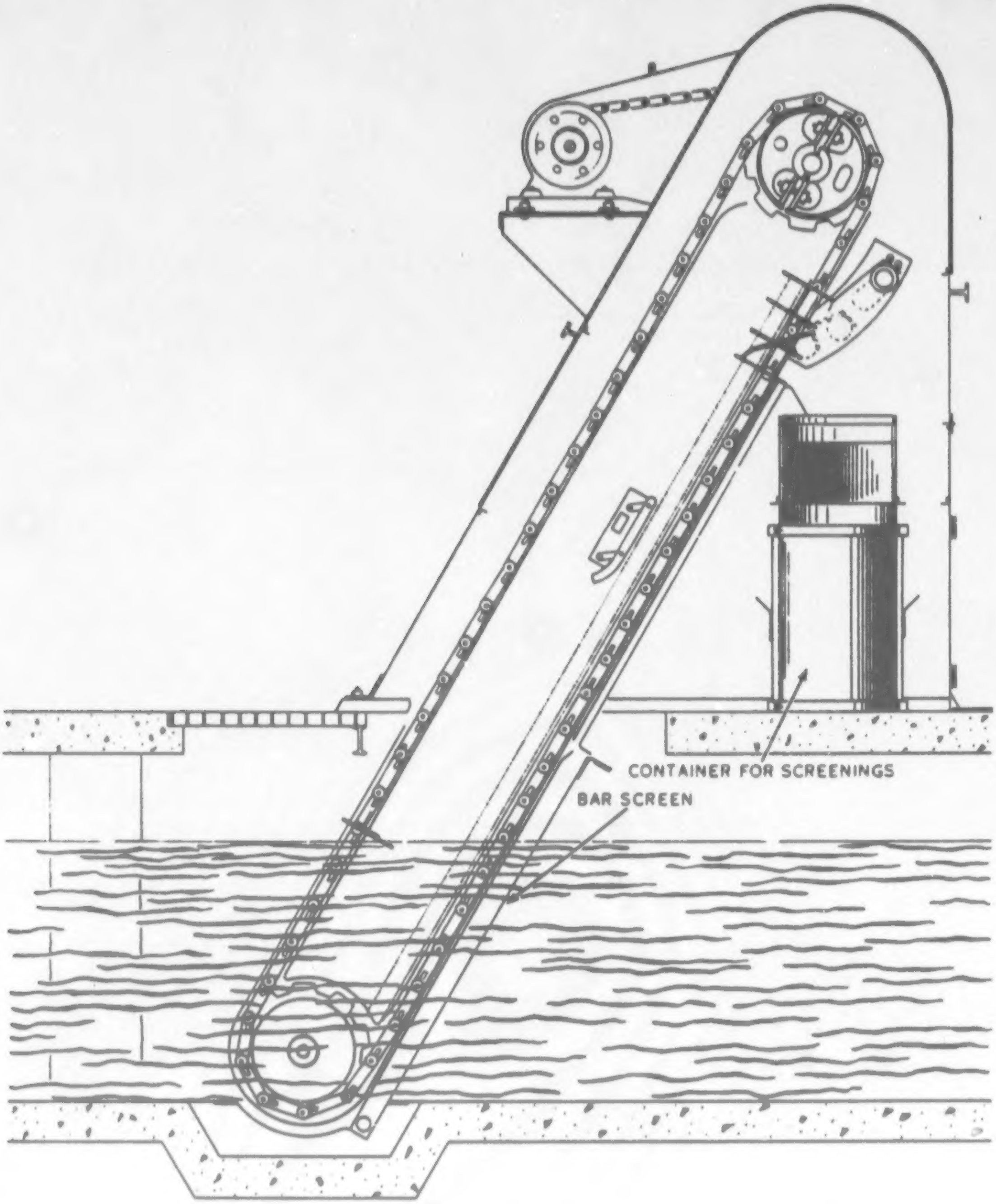
CONTAINER FOR SCREENINGS
BAR SCREEN

Figure 1. Mechanically Cleaned Bar Screen

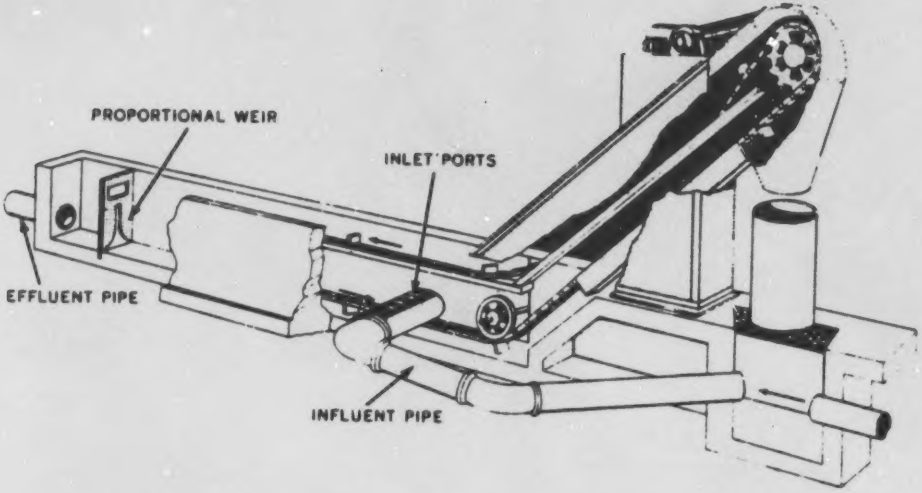
PROPORTIONAL WEIR
INLET PORTS
EFFLUENT PIPE
INFLUENT PIPE

Figure 2. Grit Chamber with Conveyor Removal Mechanism

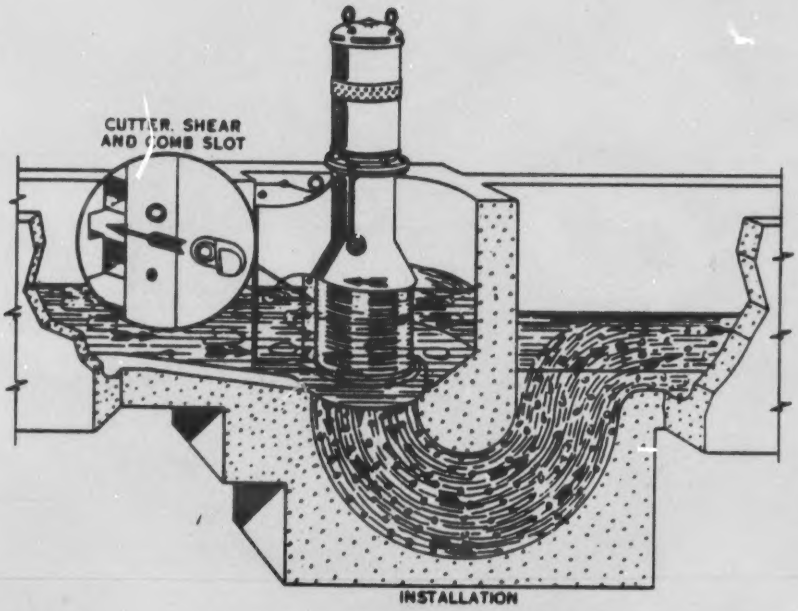
CUTTER, SHEAR AND COMB SLOT
INSTALLATION

Figure 3. Cutaway View of Comminutor

brushing, preferably with water under pressure from a hose. When the screen becomes clogged with grease it can be cleaned with kerosene. See figure 1, Mechanically Cleaned Bar Screen.

Grit Chambers

The purpose of a grit chamber is to remove the sand, gravel, glass, metal, and heavy organic matter such as coffee grounds and fruit seeds. It is an enlarged channel or long tank placed at the influent end of a treatment plant to remove the heavy, coarse, inorganic solids from the sewage. It should not remove the lighter organic suspended solids, which are intended for treatment. The cross section of the chamber is designed to retard flow velocity just enough to cause the heavier solids to settle and form a deposit that can be removed. If not removed these particles can cause pump wear and excessive wear on other plant equipment. When the velocity of the flow is reduced to one feet per second grit settles quickly. If the velocity is slower unwanted organic matter may settle and mix with the grit and cause an odor. Continuous removal equipment is available with a washing device to remove organic matter from the grit. The equipment removes the grit on an incline, moving it up by scrapers or a screw feed conveyor. This action causes the organic matter to become suspended again. If more than 15 percent of the drained grit is organic material, the chamber is improperly designed or operated.

Manually cleaned chambers usually have an alternate channel which will allow sewage to flow during cleaning operations. Grit must be removed from the compartment when it is 50 to 60 percent full and immediately after excessive sewage flow. Carefully flush the grit if it still contains organic matter; then remove it by shovel or bucket.

Mechanical removal grit equipment should be operated at intervals except at large plants. Operation must be frequent enough to prevent overloading and must be continuous during excessive flows. Organic material is washed out during the operation. Channel walls must be flushed or scraped frequently to remove grease accumulations. The metal parts above the waterline must be kept well painted to avoid corrosion. See figure 2, Grit Chamber with Conveyor Removal Mechanism.

Comminutors

These are vertical, slotted drums equipped with cutting knives revolved by an electric motor. The sewage flowing through the slotted drums forces coarse solids against the knives until they are reduced to pieces small enough to pass through the slots. The other type of comminutor, a submerged screen shredder, is semicylindrical in shape and has cutters operating within a fixed semicircular screen grid. It is usually installed in conjunction with a bar screen which may be put in service when the comminutor is shut down for repair. See figure 3, Cutaway View of Comminutor.

Grease Removal

Preaeration is a method of agitating or stirring new sewage by diffusing air through it. It was installed initially at some installations for grease removal on the principle that the emulsified particles will cling to the air bubbles and rise to the surface. Grease forms a mat that can be skimmed off. A preaeration period of from one to three hours is necessary to produce worthwhile results, including a reduction of B.O.D. Only in extreme cases is this economically feasible. The use of existing preaeration tanks is justified if needed to keep sewage fresh by resupplying the oxygen as it passes through primary tanks, for reducing odors, and for increasing the effectiveness of secondary treatment. They may also be used as grit chambers.

Vacuum flotation as a method of grease removal has the same disadvantages or limitations as preaeration. The same principle of aeration is used but with the addition of suction, supplied by a small vacuum pump, to carry solids to the surface. This process removes a little more grease than primary settling alone. Vacuum flotation, however, is sometimes used for primary settling to remove settleable solids along with grease. A detention period of 15 to 20 minutes keeps sewage fresh. They may also be used as grit chambers.

STAGES OF TREATMENT

Preliminary Treatment

This is any treatment that is done prior to the sewage entering the primary treatment system. The equipment used to perform this type of treatment may vary depending on the strength and compositions of the sewage. The equipment used may be a bar screen, grit chamber, chlorination, or aeration. In general, preliminary treatment is any treatment or preparation that is done to sewage prior to the sewage entering the settling tanks.

Primary Treatment

Primary treatment is partial and usually consists of sedimentation. An intermediate degree of treatment between primary and secondary may involve the use of chemicals to remove suspended matter from sewage. The suspended matter is coagulated or formed into settleable particles. Efficiency of this treatment varies with the sewage and the quantities of chemical agents used. The extent of treatment necessary depends on the quantity of sewage and its strength in relation to the characteristics of the receiving water. If primary treatment is sufficient to prevent stream pollution and nuisance, it is not practical or economical to add secondary facilities that increase construction, operation, and maintenance costs.

Primary treatment usually removes from 30 to 40 percent of B.O.D. and from 50 to 60 percent of the suspended solids. The components normally found in a primary plant are as follows:

1. Screens - remove large suspended and floating solids, such as sticks, rags, and other materials that may clog pumps or cause excessive scum.

2. Comminutors or grinders - grind the solids and return to sewage flow.

3. Grit chambers - remove sand, heavy solids, and materials that would increase wear on pumps and clog sludge lines.

4. Grease removal equipment - preaeration tanks, to prevent clogging filters, piping, and pumping equipment.

5. Measurement devices, such as weirs, parshall flumes, and parobolic fume and venturic meters, etc. Other devices are used to measure gas production.

6. Sedimentation or settling tanks remove settleable solids that settle to the tank bottom, where they are removed in the form of sludge.

7. Sludge digestion tanks or digesters digest and stabilize organic matter through the action of bacteria. Sludge from the settling tanks contains a large amount of water, most of which is separated from the solids during digestion and is drawn off as supernatant liquor. Digested sludge becomes a relatively inoffensive residue on the tank bottom.

8. Sludge drying beds, drain and evaporate remaining water from digested sludge.

9. Sludge pumps are usually necessary for the transfer of sludge.

10. Chlorination facilities disinfect the effluent from the treatment plant and control odor.

Primary treatment entails preliminary treatment also. In the past few years in the waste field, people have distinguished between the two as was stated earlier. If there are no settling tanks the plant is considered to have only preliminary treatment.

Secondary treatment is the means for further treatment of primary settling tank effluent by biological processes. In these biological processes, organic matter remaining in the sewage after primary treatment is stabilized through the action of oxidizing bacteria. This is ordinarily accomplished by means of a trickling filters, the activated sludge process, contact filters, intermittent sand filters, oxidation ponds, or the combinations of such facilities. Final settling tanks are required with the activated sludge process, trickling filters, and some of the combined processes. For small installations, particularly following septic tanks, secondary treatment can be provided by subsurface sand filters, tile fields and leaching wells are more for disposal than treatment. Processes commonly used in secondary treatment to stabilize the soluble and finely divided suspended sewage solids in the primary settling tank effluent are as follows:

1. Filtration - the biological oxidation of sewage solids through beds of stone or sand. Trickling filters or intermittent sand filters are commonly used with dosing tanks in high-capacity filtration.

2. Contact aeration - this is oxidation in the presence of organisms that are retained on surfaces of material in contact beds or on contact plates. Oxygen is provided by compressed air blown through the settled sewage while it is in the contact tanks.

3. Activated sludge - this method is a process of oxidation by aerobic bacteria that occurs in aerating a mixture of sewage and activated sludge is returned to the sewage entering the treatment plant to "seed" or innoculate the incoming raw sewage.

4. Subsurface irrigation- the application and disposal of treated effluent to the soil by means of underground open joint or perforated pipelines.

Tertiary Treatment

This term has come about in the last four to five years, because of future requirements for better water quality, tertiary treatment methods may become necessary to meet water quality standards. It is treatment of the effluent, or polishing after secondary treatment for reducing residual B. O. D., phosphate and nitrate removal. These processes may be physical, chemical, or biological in nature. Some processes used are: chemical precipitation, ion-exchange, activated carbon absorption, membrane separation, ammonia stripping and stabilization ponds. It can also be, any treatment after normal or present secondary treatment.

SUMMARY

In this study guide you have read about the principles of waste treatment and the equipment used. The principles being physical, chemical, and biological. The equipment used in preliminary primary secondary as being; bar screens, grit chambers, comminutors, aerators, settling tanks, digesters, etc.

QUESTIONS

1. Name the three treatment principles.

2. How does bacteria break sewage down?

3. What type of unit will remove heavy organic solids from sewage, such as sticks?

4. What type of unit will remove sand and small stones from sewage?

5. What equipment will remove grease from sewage?

6. What two types of equipment can be considered to be in primary treatment?

7. Why is chlorine added to the plant effluent?

8. What type of equipment is used for tertiary treatment?

9. What is sewage composed of?

REFERENCES

1. AFM 85-14, Maintenance and Operation of Sewage and Industrial Waste Plants and Systems.

2. AFP 161-20, Environmental Health Engineering Handbook

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PRIMARY WASTE TREATMENT

OBJECTIVE

The objective of this study guide is to familiarize you with the units and fundamental principles of preliminary and primary waste treatment.

INTRODUCTION

When you graduate and go to another base, you may be required to operate a sewage plant. This study guide will aid you in learning the fundamentals of primary waste treatment. The treatment process begins with the removal of sand, grit and large floating solid materials. This removal of solids is known as preliminary treatment. The next stage of treatment is called primary treatment which further processes the sewage to a point where it can be disposed of properly.

Waste treatment information will be covered under the following topics:

- PRELIMINARY WASTE TREATMENT
- PRIMARY WASTE TREATMENT

PRELIMINARY WASTE TREATMENT

The preliminary area of waste disposal includes the collection systems and pumping stations. A shredder and bar screen may be required at the pumping station.

Collection Systems

Collection systems at most installations are designed to receive sanitary sewage only. Most installation collection system sewer lines are laid beneath the ground surface and usually include the following facilities: house sewer pipe, lateral sewer line, branch sewer, main sewer and force mains carrying sewage under pressure from pumping stations.

Pumping Stations

When the flow of sewage by gravity is not possible, it is necessary to construct pumping stations at low points to lift the sewage to a higher elevation so it can flow to the treatment plant.

The most commonly used pumps in a sewage system are centrifugal, axial-flow propeller, turbine, and ejector pumps. Centrifugal pumps are used more than the other types due to their simplicity, efficiency of operation and smaller dimensions.

Grit Chambers, Shredders and Bar Screens

The purpose of the shredder equipment (comminutor) is to shred solids so they will not clog the equipment. The bar screen will remove large objects which may be disposed of by other methods, such as burning or burying. Refer to AFM 85-14, Part D, Section 3, page 44, Maintenance and Operation of Sewage and Industrial Waste Plants and Systems.

Metering Devices

Operators must know at all times how much sewage is being treated to insure proper plant control and sampling. Such data provides valuable records for comparing plant efficiency and future information for designing additions to the installation. Many methods have been devised to measure liquids flowing in open channels and in pipes, flowing full or partially full. Although some equipment requires elaborate and expensive apparatus, the more simple and comparatively inexpensive methods are most frequently used. The choice of method will depend on plant capacity, the treatment process utilized, and the required degree of accuracy.

Metering devices are subdivided into primary and secondary elements. Primary elements, such as weirs, Parshall flumes, and venturi tubes, produce a measurable change of head in liquids while flowing through the respective device. Secondary elements, such as float gages and indicating, integrating and recording instruments, measure the change in head.

PRIMARY METERING DEVICES. Included in this group of devices are weirs, Parshall flumes, dosing cycle, Kennison nozzles, parabolic flume, venturi meters, and venturi flume.

Weirs. Weirs are regularly formed notches or openings through which water flows. They are classified according to shape as rectangular, triangular, V-notch, trapezoidal or parabolic. Rectangular and V-notch types are the most common.

Weirs should be kept clear of debris, slime, or any fouling material that would restrict the flow of liquids. The elevation of the weir plate must be checked and the plate kept level. Accumulated solids behind the weir must be cleaned frequently.

> NOTE: See AFM 85-14, Part D, Section 5, page 51, Metering and Sewage Flow.

Parshall Flume. In open channels, the Parshall flume is often used for measuring flows. This flume has an open and constricted channel in which differences in sewage elevation above and below the constriction can be accurately translated into rate of flow. The surface rise is usually indicated and recorded by the same type equipment as used with weirs. The Parshall flume is better than the weir in that it is self-cleaning, can handle a wide variation of flow, and does not require as great a head loss. It is particularly useful where the available head is limited. The flume must be kept free from debris that may catch in the flow channel. Accumulations appearing from time to time in float wells should be removed.

Dosing Cycle. A method of measurement used in plants having a filter dosing chamber is to install a float-actuated mechanical device for counting the dosing cycles. Sewage elevations in the dosing chamber and rate of flow to the chamber during the dosing period must be known to convert dosing-cycle count to an estimate of flow. This method is widely used but is subject to considerable error because of variations in the rates of flow to the chamber. The dosing siphon may remain in operation during high flows, or the siphon may fail to air lock, permitting continuous flow to the filter without counter operation.

Kennison Nozzles. Kennison nozzles measure flow through partially filled pipes and open channels having a wide range in flow rates. This device is particularly successful for measuring raw sewage and sludges.

Parabolic Flume. The parabolic flume may be used to measure free flows through open channels or partially filled pipes. The flume measuring section has a circular inlet and parabolic outlet. Rate of sewage flow is determined by the depth of sewage in the float pipe or well connected to the flume above the invert. A gage glass and scale may be used as the secondary element to indicate rate of flow.

Venturi Meter. The venturi meter, generally used for screened sewage and sludge, measures flow under pressure in pipes. The essential part of the primary device, the venturi tube, has a constricted throat. As liquid passes through the throat, its velocity increases and pressure decreases. The differential in pressure at the inlet and throat of the tube may be measured by secondary elements such as floats in wells connected to these pressure points or by manometers or other pressure-differential instruments. The venturi meter has a high degree of accuracy and causes only a small pressure loss in the line in which it is placed.

Venturi Flume. The venturi flume, which operates on much the same principle as the venturi tube, is sometimes used for measuring flows in sewers because it does not require special structures. Little operation or maintenance is required, but passages of the flume must be kept clear of slime and accumulated solids to insure continuous operation. For the secondary element, a single float-actuated recorder may be used.

SECONDARY METERING DEVICES. Indicating, recording, and integrating instruments convert the primary measurement of head or head differential to terms of flow. They may indicate the momentary rate of flow, continuously record the momentary rates of flow on a clock-driven chart, integrate or totalize the volume of flow, or perform a combination of these functions. The simplest type of indicating instrument is a float-mounted staff gage located directly over the float well. The more complicated types are electronically controlled and may transmit from primary to receiving stations by wireless means or television. These instruments must be designed and calibrated for the type and size of primary elements with which they are used.

Application of Metering Devices. Many installations equipped for secondary treatment and chlorination have the main sewage-metering device located in the plant influent line. Since rate of flow at the point of chlorination usually differs from that at the influent, an indicating type meter is needed near the chlorinating chamber for accurate control of chlorine dosage. A weir with a float gage or water level recorder is enough.

The weir may be set in the effluent channel if it does not back up sewage into the treatment units. Location at either the influent or effluent end of the chlorine contact chamber may be made, the effluent end being preferred because the chamber is usually large enough to eliminate high approach velocities. A weir box on the effluent line may be necessary.

Primary Elements. Sewage solids accumulate in float or stilling wells, venturi rings, and behind weirs. Solids must be removed to insure meter accuracy and avoidance of odors.

Secondary Elements. Instruments providing only flow indicatation are read hourly during plant attendance. Total daily flow and maximum and minimum flows are estimated from these readings. Integrators are read each day at the same time, preferably at 0800 hours, and total daily flow is obtained by subtracting previous day's reading and multiplying by constant shown on meter case. Record charts are changed daily at same time integrator is read. Maximum and minimum flow readings are obtained from the chart.

Timing Pump Operation. Estimation of flow by timing pump operation is sometimes desired, especially in high-capacity filter plants and in activated sludge plants where recirculation of effluents is practiced. Calibration of the pumps is necessary for this operation. Calibration may be made by the following volumetric method:

- Time the pumping from a tank or sump after closing the inlet.
- Time the rise of sewage in a tank into which the pump is discharging. The head during this test must be about the same during normal pump operation.

UNITS OF MEASUREMENT. Sewage may be measured either by rate of flow (volume passing a given point in a unit of time) or by total volume. Common units and equivalents are as follows:

1. Cubic feet per second (c.f.s.) used in recording rate of stream flow and flow in storm sewers.

   1 c.f.s. = 448.83 gallons per minute (g.p.m.)

   1 c.f.s. = 646,315 gallons per day (g.p.d.)

2. Gallons per minute (g.p.m.), used in pump output and sewer flows as a rate of flow.

1 g.p.m. = 0.00223 cubic feet per second (c.f.s.)

= 1,440 gallons per day (g.p.d.)

3. Million gallons per day (m.g.d.), used in total daily flows and may be used to express rate of flow.

1 m.g.d. = 1.547 cubic feet per second (c.f.s.)

= 694.4 gallons per minute (g.p.m.)

4. Thousand gallons per day, per month, or accumulative during fiscal year (for reporting purposes).

1,000 gallons = 0.001 million gallons

e. Cubic foot, used in storage volume.

1 cubic foot - 7.48 gallons

RECORDS. The following daily records are recorded on the monthly report.

- Total flow in thousands of (1000) gallons per day.
- Maximum rate of flow in thousands of (1000) gallons per day.
- Minimum rate of flow in thousands of (1000) gallons per day.

PRIMARY WASTE TREATMENT

Aeration Units and Tanks

In some plants, grease and oil are removed by hand skimming in the settling tank. In larger plants, it is done in preaeration tanks which aerate the sewage and skim off floating material. Preaeration units at Air Force bases are operated to keep sewage in fresh condition for grit removal, to reduce odors, and to improve the efficiency of secondary treatment. Preaeration tanks are equipped with automatic grease removal equipment. Aeration is accomplished by mechanical aerators in rectangular tanks.

Primary Clarifiers

Separate settling tanks or clarifiers are single-purpose structures for removing settleable solids from the sewage. Sludge deposited in these tanks is removed to a separate digestion tank or other place of disposal.

Settling tanks, which are classified according to purpose, include primary tanks for treating raw or screened sewage, intermediate tanks located between two stages of biological treatment, and final tanks for the last stage of settling. They are classified according to method of sludge removal as hopper bottom and mechanical sludge collection tanks. Those designed for mechanical sludge removal may be rectangular, circular or square.

RECTANGULAR TYPE. Rectangular type tanks are shown in figure 1. Figure 2 is an overhead view of this tank showing the sludge and scum removal equipment. Chain conveyors sweep the sludge particles accumulated on the bottom toward the sludge hoppers at the influent end. On the primary tank, the conveyor sweeps the entire surface of the tank, forcing the scum directly to the draw-off point in front of the effluent baffle. Sludge hoppers are emptied by gravity or by pumping while tank remains in operation.

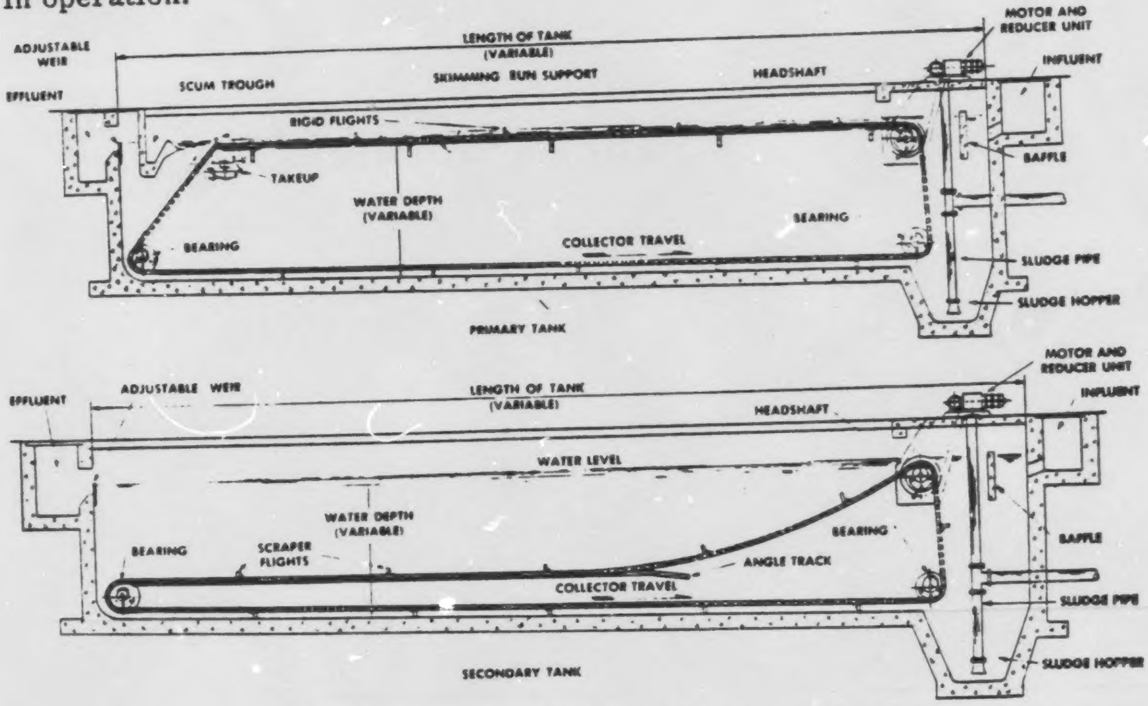
ADJUSTABLE WEIR
EFFLUENT
LENGTH OF TANK (VARIABLE)
MOTOR AND REDUCER UNIT
INFLUENT
SCUM TROUGH
SKIMMING RUN SUPPORT
HEADSHAFT
RIGID FLIGHTS
BAFFLE
TAKEUP
WATER DEPTH (VARIABLE)
BEARING
BEARING
COLLECTOR TRAVEL
SLUDGE PIPE
SLUDGE HOPPER
PRIMARY TANK
EFFLUENT
ADJUSTABLE WEIR
LENGTH OF TANK (VARIABLE)
MOTOR AND REDUCER UNIT
INFLUENT
HEADSHAFT
WATER LEVEL
WATER DEPTH (VARIABLE)
BEARING
SCRAPER FLIGHTS
BEARING
ANGLE TRACK
COLLECTOR TRAVEL
BAFFLE
SLUDGE PIPE
SLUDGE HOPPER
SECONDARY TANK

Figure 1. Rectangular Settling Tank and Mechanism

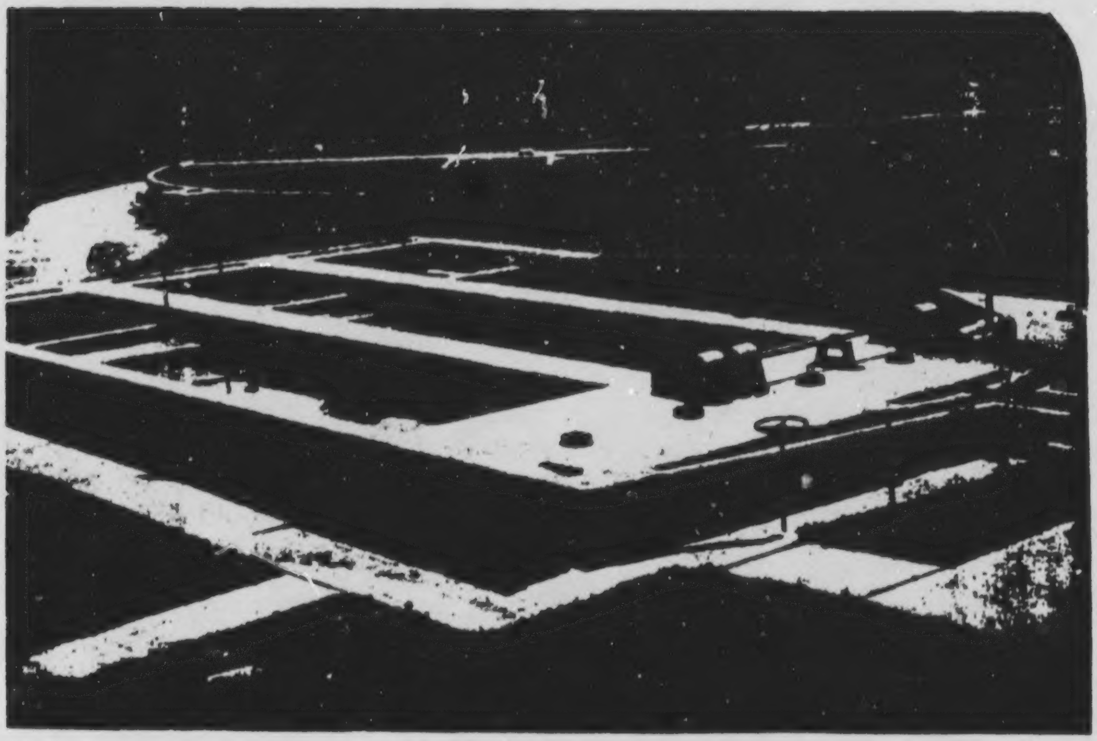

Figure 2. Rectangular Tank Showing Skimming Action of Mechanism

CIRCULAR TYPE. The circular type tank with mechanical sludge collection is illustrated in figure 3. Figure 4 is a cut-in view of a circular tank, showing the type of sludge collector mechanism. The influent comes through a centrally located, inverted siphon surrounded by a submerged diffuser which introduces the feed quietly, well below the surface, distributing it evenly to all parts of the tank.

HOPPER TYPE. Sludge can be removed from hopper tanks through withdrawl pipes without the necessity of emptying the tanks or interrupting operation. Hoppers, which take the place of a sludge collector mechanism, are suitable for smaller installation. Figure 5 shows a multiple hopper settling tank.

DETENTION PERIODS. The normal detention periods of primary and secondary settling tanks should be 2.5 hours for average daily flow, except

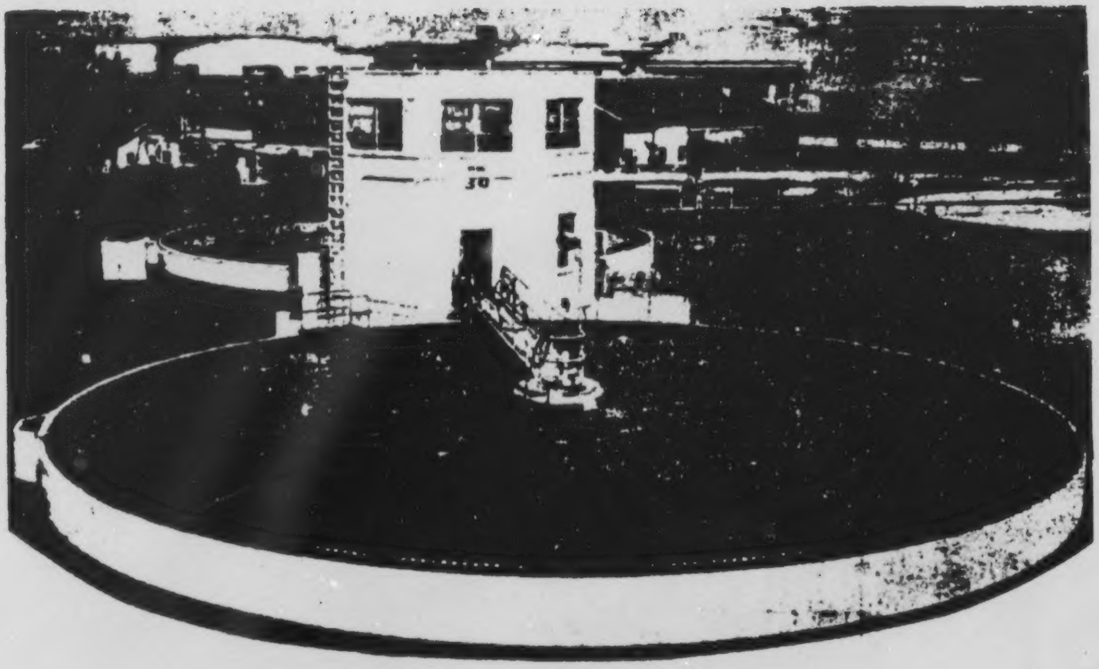

Figure 3. Circular Primary Settling Tank

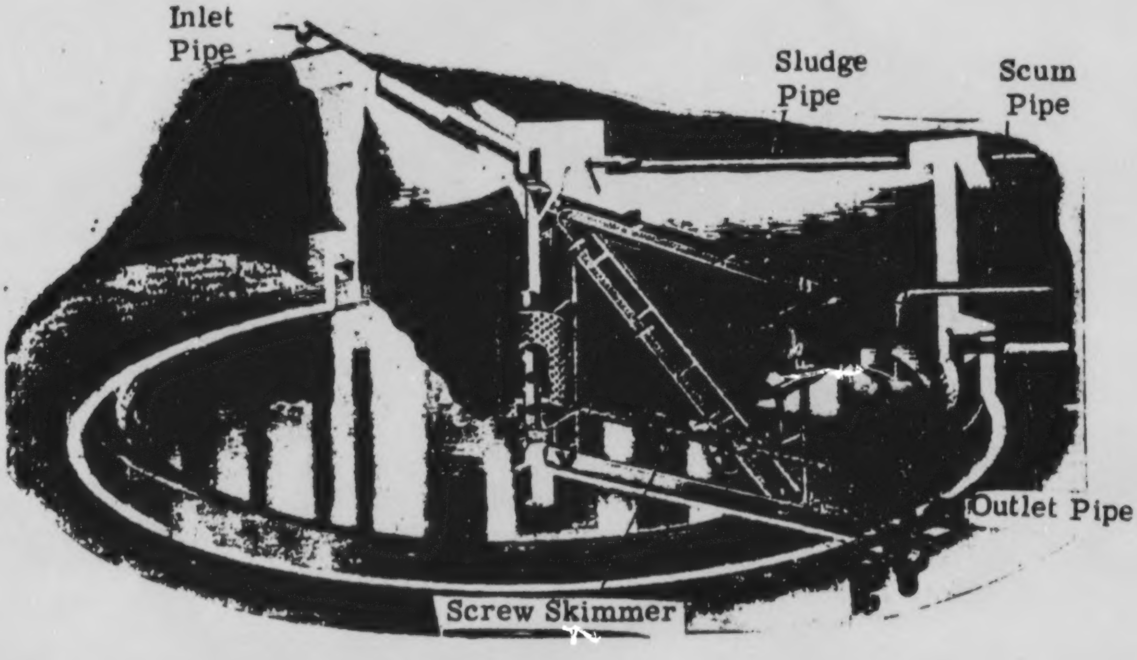
Inlet Pipe
Sludge Pipe
Scum Pipe
Outlet Pipe
Screw Skimmer

Figure 4. Circular Primary Settling Tank

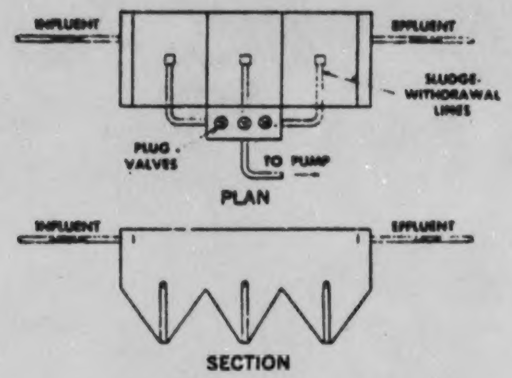

Figure 5. Multiple-Hopper Settling Tank

for activated sludge plant primary tank which should be 1.5 hours. Excessive detention may cause septic sewage, produce odors, and increase the load on secondary treatment units. Where duplicate units are used, long detention periods are avoided by removing one or more tanks from service during continued low flows or by recirculating effluent from secondary units through the primary tank. When removal of solids by settling tanks is far below normal (50 to 70 percent suspended solids), the cause is determined; operators constantly look for ways to improve operation.

OPERATION. Good housekeeping at the settling tank is essential to prevent odors, flies, and unsightly appearance. Floating solids passing out with the effluent may clog filtering equipment; grease may cause ponding of filter media.

Floating Material Removal. Floating material must be removed once each shift or oftener if present in large quantities. Some mechanical skimmers automatically remove material to a sump for disposal; other tanks have a manually operated skimming pipe. However, a hand skimming tool should always be used to facilitate entrance of skimmings into the pipe or trough. Where skimmings are pumped to the digester, a minimum of sewage and wash water should go with it to prevent upsetting the digester operation. If large quantities of fairly dry skimmings tend to upset digestion, they should be collected in a covered can with openings for draining excess water and hauled to a sanitary fill or incinerator. The can must not be placed where drainage becomes a nuisance. If a fill is not available, skimmings are drawn to a trench and covered with at least 2 feet of earth. A spray of water under pressure directed against floating material frequently settles floating material.

Cleaning Sidewalls. Sidewalls of channels, baffles, weirs, launders, and tanks are kept clean of grease and other solids by hosing, scraping, or brushing once each day or oftener if necessary.

Dead ends and corners are brushed at least once each shift and fine sand and gravel are removed for burial or used as fill.

Decks and walks are hosed at least once each day. Where pressure is not available for hosing, secondary effluent may be used with a portable pump, pressure system, or other pumping equipment.

Grit Removal. If grit appears in channels or hoppers, grit chamber operation is checked. If the unit has not grit chamber, one should be installed if necessary. However, since grit is a sign of breaks in the sewer system or storm water connections, the system should be checked thoroughly before a grit chamber is constructed.

Sludge Withdrawl. Proper sludge withdrawl is important to settling efficiency. A flexible schedule of withdrawing concentrated sludge must be established with the following factors considered.

The sludge's solids content should be as high as possible. This means a slow rate of withdrawal and stopping withdrawal when sludge becomes thin.

Water volume in the digester must be reduced wherever possible because this volume directly affects digester operation. A decrease in solids content causes a larger volume of sludge to be heated, a greater volume of digester supernatant to be returned, and reduction of effective capacity. Example: 3 pounds of dry solids pumped as a 3-percent sludge puts into the digester 97 pounds, or about 11.7 gallons of water; the same dry solids pumped as a 6 percent sludge introduces 47 pounds or about 5.65 gallons of water, about half as much. Sludge must be drawn slowly (50 to 60 g.p.m. or less) to avoid pulling light sludge and sewage to the intake; it is sampled during the drawing to note the consistency and obtain the composite sample. A quick-opening 2-inch valve must be provided for sampling, if other means are not available. Sludge of thin consistency can be recognized from experience by correlating its appearance with sludge solids test results.

Hopper bottom tanks, used as separate settling tanks, require more care in drawing sludge because of the larger number of hoppers. Sludge from the hoppers at the effluent end normally has a low solids content, but must be removed to prevent carrying over with the effluent Hoppers are squeegeed several times each week to remove adhering solids.

The interval between removals is regulated by sewage load and weather conditions. Shorter intervals are required during high flows of strong sewage and during warm weather. If sludge rises from the hoppers, removal is incomplete or too infrequent.

Sludge should normally be removed from primary settling tanks three to four times each 24 hours. Sludge collected in settling tanks following standard trickling filters is drawn at least once each day, except during filter sloughing when more frequent withdrawal is advisable.

Good judgment is necessary to obtain a balance between high solids concentration and a clean tank bottom, especially where light sludge from secondary processes is returned to the primary tank for resettling.

Mechanical sludge collectors in circular tanks and all settling tanks for activated sludge must be operated continuously. Intermittent operation of circular tank mechanisms cause solids to accumulate on the tank floor placing a large starting load on the mechanism. Continuous operation provides greater sludge compaction. Sludge collectors in rectangular tanks are not usually operated continuously although it may be done, especially when the sewage is strong and the rate of flow high. The mechanism should normally be started from 1 to 2 hours before pumping, tank length governing length of this period somewhat. At least two complete runs for the length of the tank is desirable. The tank bottom must be well cleaned and old sludge completely removed to the hoppers. Rising gas bubbles and sludge along the tank indicate incomplete cleaning or too long a period between operation. Hoppers in rectangular tanks should not be filled more than 6 inches from the top. In withdrawing sludge, 2 feet of sludge blanket may be left in the hopper. Where there are two or more hoppers, only one should be drawn at a time.

The daily volume of sludge removed is measured by the following methods:

- Where sludge is drawn to an open sump before pumping to the digester, calculate volume of the sump per foot of depth. Measure depth of sludge in the sump by calibrating a rod in reverse so that the measurement may be made from the top of the sump to the surface of the sludge.

- Where sludge is pumped directly from the clarifier, estimate volume by minutes of pump operation multiplied by actual gallons per minute output. This requires calibration of the pumps. If reciprocating pump valves clog, time while clogged is not included.

- Where floating covers are installed in digesters, check volume of sludge pumped in several days against the above calculation by the rise of the cover. This procedure is one way to calibrate the sludge pump.

Methods of Control. Suspended solids and settleable solids tests are primary measures of efficiency since solids removal is a primary function. Proper operation should remove 90 percent of settleable solids and 50 to 70 percent of suspended solids. Low solids removal may be caused by short circuits in the tank, incomplete removal of sludge, incomplete collection of sludge from tank floor, short detention period causing high velocities, or long detention periods allowing gas formation in tank.

BOD removal is a secondary measure of tank efficiency. Low BOD removal with normal suspended solids removal usually indicates septic action caused by an excessive detention period or incomplete sludge removal. Also indicative of these conditions is a pH value of the tank effluent lower than that of the influent.

Analysis of sludge samples for solids content, sampling the tank bottom for presence of solids and appearance of rising gas or sludge indicates whether or not the methods of removal are effective.

Causes of low efficiencies must be determined and corrected; continued difficulty is reported to higher authority for advice and correction.

RECORDS AND REPORTS. The following data is reported monthly:

- For influent and effluent of tank; settleable solids, pH, suspended solids, and BOD.

- For primary tank sludge; volume removed, pH, percent solids, percent volatile matter.

- Changes in the number of tanks in operation.

In addition to the data required monthly, the following daily records are kept:

- Volume of sludge returned or recirculated to raw sewage or other plant units (refers generally to secondary sludge).

- Volume and dispostion of skimmings.

- Remarks on operating difficulties.

Imhoff Tanks. The main features of the Imhoff tank are shown in figure 6. Sewage flows slowly through the upper (settling) compartment and settleable solids pass through a slot in the hopper bottom into the lower (digestion) compartment. The slot is trapped from below by an overlap in the sloped walls of the hopper bottom. As anaerobic decomposition takes place in the digestion compartment, the gases produced rise but are diverted by the overlapped slot into a separate gas vent. There the gases may be collected for fuel or more commonly are allowed to escape to the atmosphere. Solid particles rising with the gases are similarly prevented from entering the settling compartment. This separation of settling and digestion processes permits more efficient settling unhindered by disturbance from rising gases, keeps sewage in the upper compartment fresh, makes digestion more complete, and produces a better effluent. Digested sludge is withdrawn by gravity (hydrostatic head), or pumping through a sludge pipe from the bottom of the digestion compartment. A settling tank detention period of 2-1/2 hours for average flow is usually provided for Air Force installations. The speed of sludge digestion depends chiefly on temperature, so the sludge-holding capacity of Imhoff digestion compartments, which are unheated, may be decreased for higher temperature and increased for lower temperature areas. A sludge capacity of 3 to 4-1/2 cubic feet per capita is average.

OPERATION AND CARE OF SETTLING COMPARTMENT. Imhoff tanks require regular, frequent attention to maintain efficiency and to minimize odor and sight nuisances.

Regulation and Reversal of Flow. Proper distribution of the influent to the settling compartment is essential to efficient settling. Where two or more units are installed, flow is distribution between units by adjusting the influent gates. Properly placed dividing lines of bricks or triangular blocks of concrete may sometimes be used in the influent channel to divide the flow. Leveling of outlet weirs is necessary to equalize distribution between units. Many long tanks, where most of the solids may tend to settle at the influent end, have channels to reverse the flow, using the entire digestion space to full capacity. If uneven sludge distribution occurs,

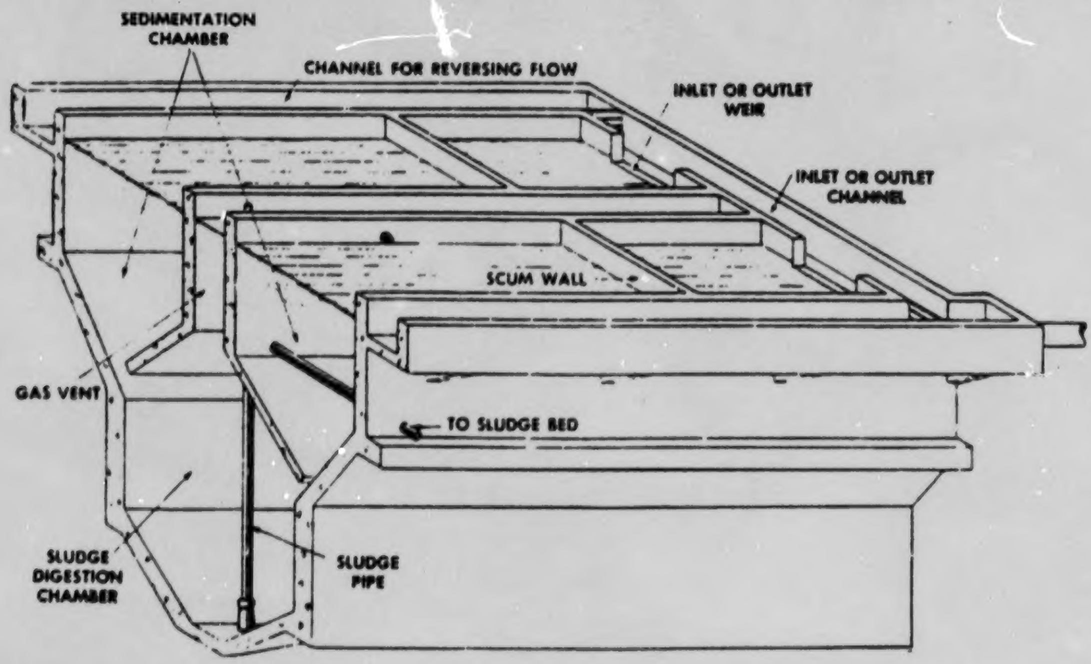
SEDIMENTATION CHAMBER
CHANNEL FOR REVERSING FLOW
INLET OR OUTLET WEIR
INLET OR OUTLET CHANNEL
SCUM WALL
GAS VENT
TO SLUDGE BED
SLUDGE DIGESTION CHAMBER
SLUDGE PIPE

Figure 6. Sectional View of Imhoff Tank

flow must be reversed each month. Settling compartments have influent and effluent baffles, which should not extend more than 18 inches below the sewage surface. The influent baffle distributes incoming flow more equally across the entire compartment.

Cleaning and Scum Removal. Care must be taken in all tank cleaning operations to avoid excessive stirring of sewage, which interferes with natural settling and may cause skinnings to pass under baffles. All walks, tops of walls, and exposed interior walls should be cleaned by hosing and scraping once a day. The channels and tank walls of the settling compartments must be kept clean and free from grease, scum and gritty deposits. Scum on the surface of the flow compartments must be skimmed off. Skimmings should not be placed in gas vents, where excessive amounts produce odor nuisance. Skimmings should be transported daily in covered containers to an incinerator or sanitary fill or buried promptly with a thin cover of earth and recovered with an additional 6 inches of earth after 24 hours. A spray of water (final effluent may be used) helps to settle floating solids in the settling compartment (see figure 7). Solids sticking to the upper sides of the hopper bottom of the settling compartment must be

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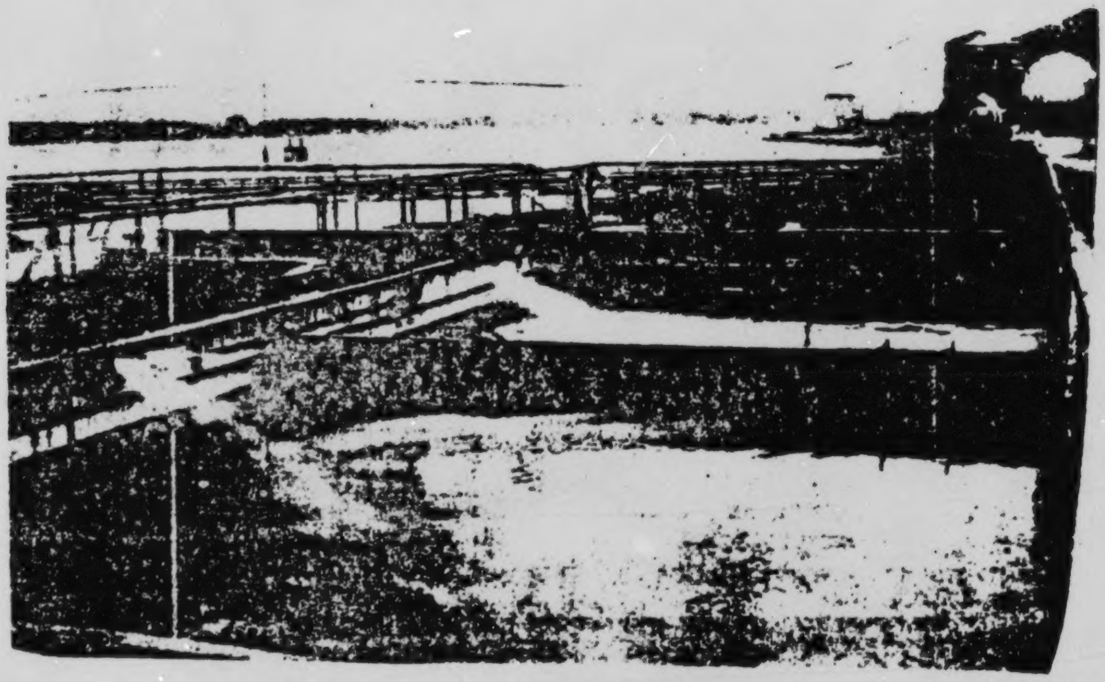


Figure 7. Water Spray Used to Settle Floating Solids

pushed through the slots weekly or more often if necessary. A long-handled squeegee is a suitable tool for this purpose. Slot cleaning is accomplished by dragging a heavy chain, attached to a pole, along the slot (see figure 8).

OPERATION OF DIGESTION COMPARTMENT. Digestion compartments in Imhoff tanks and in separate sludge digesters operate in a similar manner.

Control of Sludge Level. Sludge must not be allowed to accumulate above a level of 2 feet below the slot in the settling compartment. If the slot is not adequately trapped, it is necessary to keep the sludge level much lower to prevent the sludge solids from passing up through it. Sludge must be withdrawn frequently enough to maintain the proper level; small draw-offs, monthly or more often, should be made, rather than large draw-offs at longer intervals. Only well-digested sludge should be withdrawn, leaving enough in the compartment to prevent acid digestion and foaming. Usually, not more than half the depth of sludge should be removed at one time. In northern climates, however, sludge must be

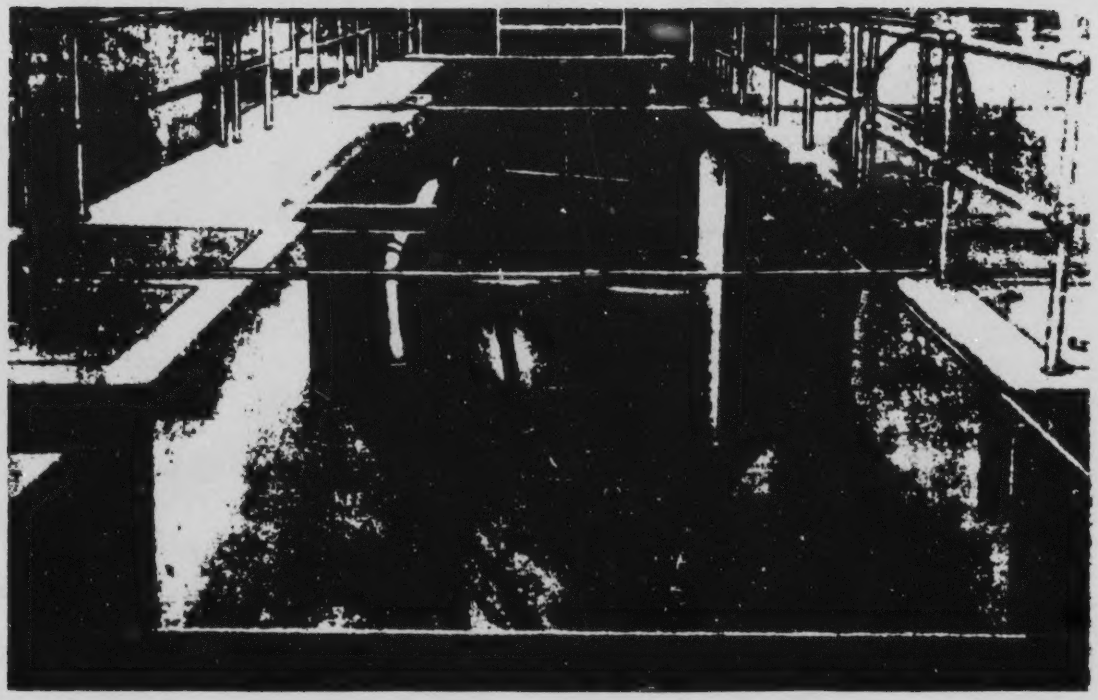


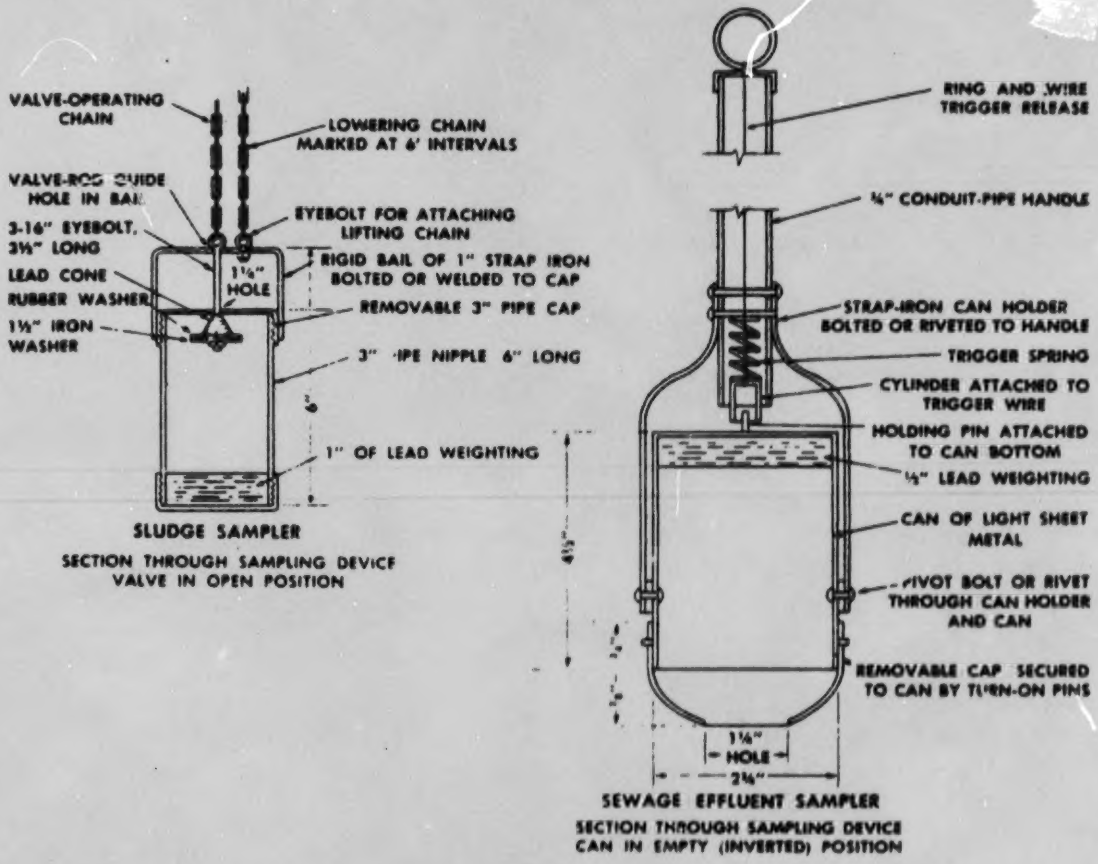
Figure 8. Empty Settling Compartment Showing Hopper and Slot

drawn down far enough during summer and autumn to allow ample room for winter accumulations when sludge digestion proceeds more slowly. The availability of sludge drying beds regulates withdrawal at some plants. Sludge must be drawn down during dry seasons to allow sufficient capacity in the sludge compartment for long rainy reasons when sludge drying may not be possible.

Measurement of Sludge Depth. When the tank is operating at near capacity or there is a possibility of overloading, the depth of sludge in the digestion compartment should be measured or sounded weekly at both inlet and outlet ends of the tank. Monthly soundings are sufficient if the sewage load is less than 75 percent of rated tank capacity. The most effective method of sounding is the use of a pitcher pump with a rubber suction hose.

A hand pump of the pitcher type is equipped with a rubber suction hose, which is marked for length at 2-foot intervals and weighted at the end. With the pump in operation, the hose is lowered through the slot in the settling compartment. The length of hose submerged when sludge first appears equals the sludge depth. A variation of this pitcher pump method involves the use of a graduated rubber suction tube weighted by a 4-foot steel pipe that forms part of the suction line. The tube is lowered through the gas vent instead of the slot; otherwise, the measuring procedure is the same.

A sludge sampler, figure 9, may be used to measure sludge depth, lowering it through the gas vent into the sludge compartment and taking samples at consecutively deeper points until the sludge level is reached.


VALVE-OPERATING CHAIN
LOWERING CHAIN MARKED AT 6' INTERVALS
VALVE-ROD GUIDE HOLE IN BAIL
EYEBOLT FOR ATTACHING LIFTING CHAIN
3-16" EYEBOLT, 3½" LONG
1¼" HOLE
RIGID BAIL OF 1" STRAP IRON BOLTED OR WELDED TO CAP
LEAD CONE
RUBBER WASHER
REMOVABLE 3" PIPE CAP
1½" IRON WASHER
3" PIPE NIPPLE 6" LONG
6"
1" OF LEAD WEIGHTING
RING AND WIRE TRIGGER RELEASE
¼" CONDUIT-PIPE HANDLE
STRAP-IRON CAN HOLDER BOLTED OR RIVETED TO HANDLE
TRIGGER SPRING
CYLINDER ATTACHED TO TRIGGER WIRE
HOLDING PIN ATTACHED TO CAN BOTTOM
½" LEAD WEIGHTING
4½"
CAN OF LIGHT SHEET METAL
PIVOT BOLT OR RIVET THROUGH CAN HOLDER AND CAN
REMOVABLE CAP SECURED TO CAN BY TURN-ON PINS
1¼" HOLE
2¾"

SLUDGE SAMPLER
SECTION THROUGH SAMPLING DEVICE
VALVE IN OPEN POSITION

SEWAGE EFFLUENT SAMPLER
SECTION THROUGH SAMPLING DEVICE
CAN IN EMPTY (INVERTED) POSITION

Figure 9. Samplers Designed for Collecting Sewage and Sludge

An iron plate on a weighted wood block, 12 to 18 inches square, can be attached to a graduated wire or chain and lowered through the gas vent. The plate stops when the sludge level is reached and the distance from the surface to the sludge level may then be measured to determine the sludge depth.

Sludge Removal. Well-digested sludge is black and granular, with an inoffensive tarry odor, a pH normally above 7.0 and a volatile solids content of about 50 percent. It drains and dries readily on sand beds and does not breed flies on beds during drying periods. Digested sludge must be drawn off slowly to allow the mass to settle evenly and prevent the formation of a cone above the sludge outlet. Such a cone would permit partially digested sludge or even raw sewage to be withdrawn, creating odor nuisance and sludge drying difficulties.

If the outlet pipe clogs, flow may be started by applying recirculated effluent or water under pressure (not connected to the potable water system) through a hose immersed in the sludge riser pipe. Opening and closing the sludge valve may also relieve clogging. Sludge may also be agitated or stirred with long rods inserted through slots, gas vents, or riser pipe. After sludge is withdrawn, the sludge lines must be flushed out or filled with water (unless there is danger of freezing) to prevent drying and hardening of solids in the pipes.

Gas Vents or Scum Compartment. Solids rising with digestion gases accumulate and form scum in gas vents. This scum must be broken up as frequently as necessary to allow the entrapped gases to escape and floating matter to drop back into the digestion compartment. One or more of the following methods may be used: breaking up the scum with a rake or hoe; hosing scum with water under pressure using a fine spray; keeping the scum wetted down with water, or preferably liquor from the digestion compartment by means of a portable pump. The use of large quantities of water should be avoided because it creates subcurrents. Heavy dry scum should be shoveled off when 2 to 3 feet deep and placed on drying beds. In cold weather, frozen scum must be removed frequently so that gas escape is not blocked.

Foaming. Foaming is indicated by the rise of large amounts of black, sudsy, offensive scum in the upper part of the digestion compartment, in gas vents, and in some cases, through the slots. Acid digestion, with a lowering of pH and the formation of gas with a high carbon dioxide content, follows this condition; if it is not checked, the foam may overflow into the settling compartments and carry with it suspended solids from the digestion chamber.

Causes. Foaming occurs when raw solids accumulate faster than they can be digested and is usually brought about by the following:

1. Starting the tank without first seeding the sludge with well-digested matter; this is especially applicable when new tanks are placed in service.

2. The change to warmer weather from low winter temperatures when there has been a lack of digestion.

3. Excessive withdrawal of digested sludge.

4. High grease content of sewage solids and high calcium soap content from hard waters.

5. Insufficient digestion capacity.

Controls. Careful operation will usually prevent foaming. If it occurs, the following methods will control or minimize it:

1. Mixing digested sludge with raw sludge before starting the tank.

2. Periodic heavy hosing or use of a continuous water spray to break up the foam.

3. Application of sludge or sludge liquor from the hopper bottoms to the gas vents by means of an air lift or portable pump, thus mixing the foam with digested sludge.

4. Addition of hydrate lime slurry if sludge pH is below 6.5. Add sufficient lime in this suspension direct to the sludge compartment by means of a pipe inserted into the gas vents at different points. Add sufficient lime to adjust the pH to 7.0.

5. Putting the tank out of service until the foaming subsides, which is the most effective method when at least one other tank is available, or reducing the flow to the foaming Imhoff tank avoiding a detention of more than 6 hours to prevent septic conditions.

6. Drawing off incompletely digested sludge if the compartments are heavily loaded; an application of hydrated lime to the sludge during withdrawal helps to reduce odors and fly breeding on the drying beds.

7. Where digester capacity is inadequate and additional construction is delayed, building deep temporary lagoons that will provide additional digester capacity and are equipped for sludge removal to drying beds.

CONTROL METHODS FOR IMHOFF TANKS

Settling Compartment. The settling compartment is controlled in smaller plants by settleable solids tests and pH determinations. Tests for suspended solids and BOD are added for larger plants. Normal operation should result in a settleable solids reduction of 90 percent or more, a suspended solids reduction of 50 to 70 percent, and a BOD reduction of 30 to 40 percent. Causes for lower efficiencies should be determined and corrected.

Digestion Compartment. Digestion compartment control is guided by weekly or monthly sampling of sludge depth and sampling of digested sludge at the bottom of the compartment before sludge is drawn to the drying beds. Tests for sludge pH are made at all plants, and tests for total solids and volatile solids at larger plants when directed. Experienced operators can tell when sludge is well digested by its granular appearance and tarry odor.

Oil and Grease in Sewage Flow. Oil and grease in raw sewage entering an Imhoff tank or other treatment unit causes difficulties such as interference with digestion, floating of solids, and increase of BOD. Such wastes should be intercepted before entering the sanitary sewer system.

Digesters

Organic matter in sludge furnishes food for bacteria and other microorganisms; while passing through them, it breaks down into simpler and more stable substances. This is the basis of the sludge digestion process, which produces three final products: digested sludge, supernatant liquor, and gas. Digestion reduces the volume of sludge to be handled, simplifies disposal, and provides a more stable and inoffensive product that under certain conditions may be used as a soil conditioner. The organic matter in sludge is reduced to simpler and more stable forms and a considerable part of the solids are changed to liquids and gases. Digested sludge is dried on drying beds; supernatant liquor is returned to the raw sewage entering the plant; gases are burned or used to provide heat or power for the digester or treatment plant. Gas may also be used to operate gas engines for pumping or other plant purposes.

There are three types of digestion tanks. They will be covered in the following paragraphs.

UNCOVERED TANKS. Uncovered tanks are usually hopper-bottom tanks without gas collection or heating equipment. They are used on small units or for storing partly or fully digested sludge from other digesters.

FIXED COVER TANKS. Fixed-cover tanks may be used for economy on single, two-stage, or two-story digestion tanks. It is also necessary that they be used under conditions where snow and ice would interfere with the movement of floating covers. Because the fixed-cover digester must be kept full to keep out air, withdrawal of supernatant liquor must be done at the same time and in the same amount as the addition of fresh sludge.

Digesters of this type are usually concrete structures with sloping bottoms; they may or may not be equipped for heating and mixing sludge and for scum-breaking. The cover may be a flat or domed concrete slab with or without space for gas between it and the liquid level in the tank. More commonly, gas space is provided by a small dome of concrete, usually located in the center of the cover (see figure 10). The gas dome and seal are usually connected to a boiler or waste burner and must always be provided with a flame arrester. Heating the sludge is accomplished by external heating or by passing hot water through pipes arranged in coils near the inside walls or hung from the roof of the tank. External sludge heating is a more recently developed method of maintain proper sludge temperatures.

FLOATING COVER TANKS. Floating cover tanks are of two kinds: one is equipped with a cover that "floats" on or moves up and down with the liquid level in the tank; the other has a gas-holder cover that is supported by the gas pressure in the tank. (See figure 11.)

> CAUTION: Sludge must not be withdrawn from a floating cover tank when the cover is at its lowest position and resting on its support brackets.

STAGES. There are three stages in the digestion of fresh sludge, due to the fact that the compounds in sewage breakdown or decompose at different rates. A highly acid stage marked by a lower pH and production of gas with a high carbon dioxide content is soon followed by a less acid stage, and finally by a fermentation stage in which the pH rises towards the alkaline side of the pH scale. After the third stage is reached, BOD decreases sharply, most of the floating solids have settled and methane

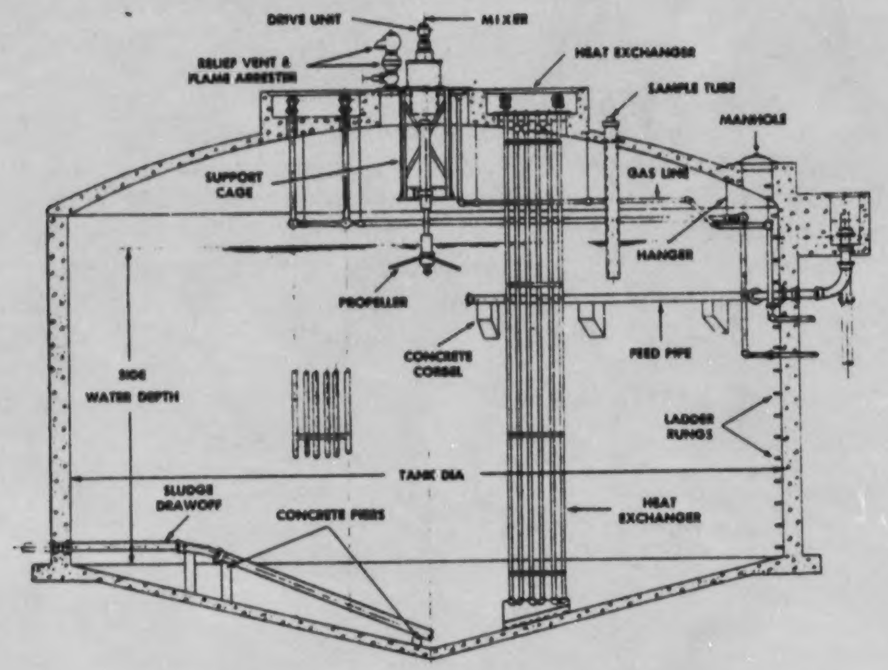

DRIVE UNIT
MIXER
RELIEF VENT & FLAME ARRESTER
HEAT EXCHANGER
SAMPLE TUBE
MANHOLE
SUPPORT CAGE
GAS LINE
HANGER
PROPELLER
CONCRETE CORBEL
FEED PIPE
SIDE WATER DEPTH
LADDER RUNGS
TANK DIA
SLUDGE DRAWOFF
CONCRETE PIERS
HEAT EXCHANGER

Figure 10. Digester with Fixed Cover

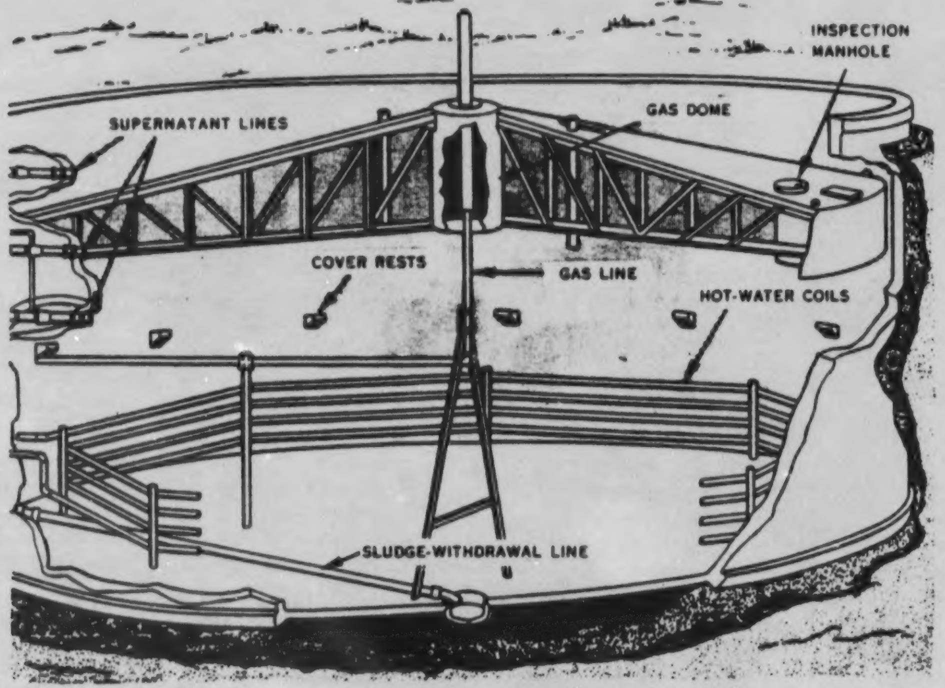

INSPECTION MANHOLE
GAS DOME
SUPERNATANT LINES
COVER RESTS
GAS LINE
HOT-WATER COILS
SLUDGE-WITHDRAWAL LINE

Figure 11. Floating Cover Digester

gas is produced in volume. In a properly operated digester, the three stages proceed simultaneously on the solids in the order of their age in the digester. When a digester is placed into service, the first two stages prevail for some time, with the third stage starting later. After the third stage is established, fresh sludge may be added without appreciably affecting the characteristics of the tank contents. The three stages gradually merge until little evidence of the acid stages remains. Rapid digestion follows with heavy evolution of gas with high methane content. The resulting sludge is relatively stable and can be handled without any considerable odor nuisance.

TEMPERATURE. Temperature determines the rate of digestion. Mesophilic digestion, which progresses best between 40° and 105°F, is generally used. Above 105°F, the organisms of mesophilic digestion become inactive and thermophilic digestion occurs. The latter range is not presently used because of the odors and operating difficulties. Approximate time of digestion at different temperatures can be determined from figure 12. Between 90° and 100°F, well-digested sludge is produced in about 24 days. At 85°F, 90 percent of digestion is completed in 26 days; at 75°F, 35 days; and at 55°F, 65 days. High temperatures are more difficult to maintain and require considerable heat transfer, especially in the cold climates. The practical operation range is between 85° and 95°F.

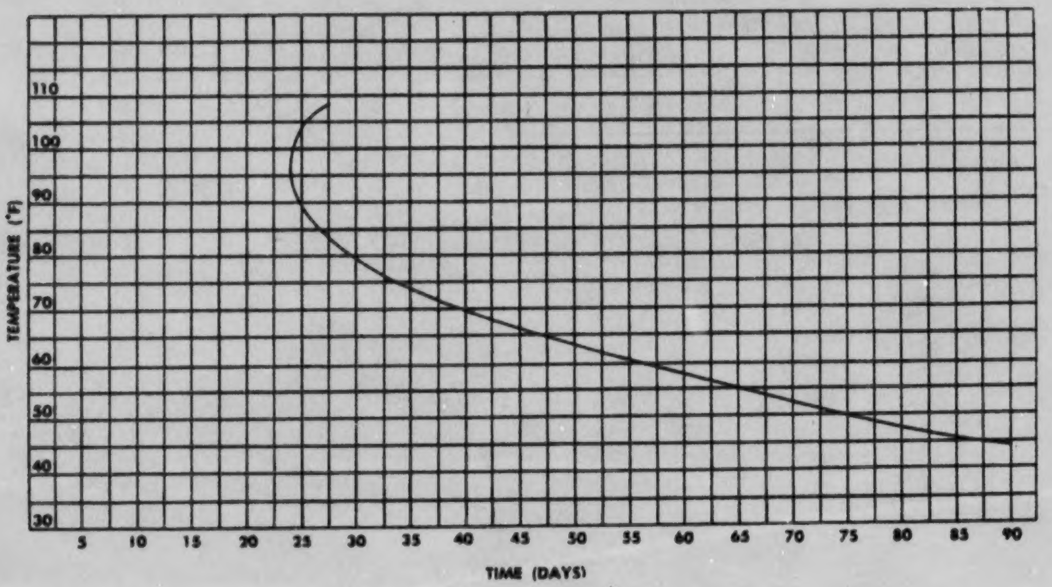


Figure 12. Time Required for Digestion of Sewage Solids at Different Temperatures

NOTE: Detailed information and materials covered to this point in the study guide may be found in AFM 85-14, Maintenance and Operation of Sewage and Industrial Waste Plants and Systems, Part D, Sections 2 thru 8, pages 41 thru 100.

DIGESTER OPERATION - GENERAL INFORMATION. The type of tank, disposal facilities, and season of year govern digested sludge withdrawl. Some digested sludge should be left in the tanks to seed the incoming raw sewage and maintain balanced alkaline fermentation.

Well-digested sludge is usually granular, has an odor similar to that of tar, and is dark in color. Gray or light brown stripes in the sludge are signs of incomplete digestion.

The sewage gas is commonly used for heating water to maintain digester temperature; other uses include building heating, laboratory burners, screenings, and grease incineration, or fuel for gas engines driving pumps, blowers or electric generators. Excess gas is burned in a waste gas burner.

Special gas burners, usually installed at the treatment plant, have a pilot line burning either digester or domestic gas and a digester waste gas supply line. If digester gas is used for the pilot line, the pilot line connects from the waste gas line ahead of the pressure relief and flame trap assembly to provide a constant source.

Some safety devices found on digesters are drip traps for collecting moisture in the digester gas lines. Pressure-vacuum relief units for relief of pressure in the digester and to allow air to enter the digester if a vacuum is produced. A means to stop flames which might cause digester explosion is provided by a flame arrester.

Boilers are sometimes provided to heat water which is circulated through the sludge digester to heat the sludge. The boiler should be operated at a temperature of 180°F to prevent excessive moisture in the flue. Circulating water is kept at 140°F or less by the thermostatically controlled three-way valve which mixes the water from the boiler with the cooler water direct from the coils of the digester or by manual setting of valves in the lines.

Many gas distribution systems have gages or manometers to measure the actual gas pressure in various parts of the system. By observing these gages, the operator can tell when there is moisture in the system. Normally, three gages are used to measure pressure; at the digester, point of use, and supply to the waste gas burner.

Records must be kept on the digester and gas equipment to help the operator keep the system in good operating condition and to provide for the proper management of sludge, supernatant liquor, and gas.

Sludge Drying Beds

Sludge is removed from digester or Imhoff tanks to drying beds or a mechanical filter where the digested sludge is dewatered and dried. This process may be accomplished through the use of drying beds or mechanical filtration. The dried sludge may then be disposed of in several different ways. It will be necessary to keep accurate records of the operation on a monthly operating log.

Well-digested sludge from the separate sludge digester or Imhoff tank has a water content of 90 to 96%. Digested sludge is generally dewatered at the treatment plant by underdrained sand and gravel beds, although natural sand areas are sometimes used. This sludge drying takes place both by evaporation from the surface and by drainage through the sand and gravel. Water drainage through the bed is returned to the raw sewage flow wherever possible. When plant elevation makes this impraticable, it is discharged to other points in the plant or to the receiving stream; in most cases, it goes directly to the stream.

CONSTRUCTION FEATURES OF SLUDGE DRYING BEDS. In the construction of an underdrained sludge bed, the ground is dug to the desired depth and graded to form furrows. In these, open tile drains are laid in surrounding beds of gravel 6 to 12 inches deep. From 6 to 12 inches of sand is placed on top of the gravel and leveled. Outside walls and partitions between adjacent beds may be constructed of concrete, wood, or earth. The number and size of beds required depends on plant size and average drying time. Figure 13 shows a typical sludge bed. Glass covers, such as those used for greenhouses, may be installed over beds to increase drying efficiency, to provide all-weather drying and to eliminate odor nuisance.

DRYING BED OPERATION. Effective sludge drying depends primarily on the condition of the sludge from the digester. Poorly digested sludge forms a heavy mat over the sand and sludge surface which slows drying. Sludge withdrawals from digesters and Imhoff tanks should be scheduled

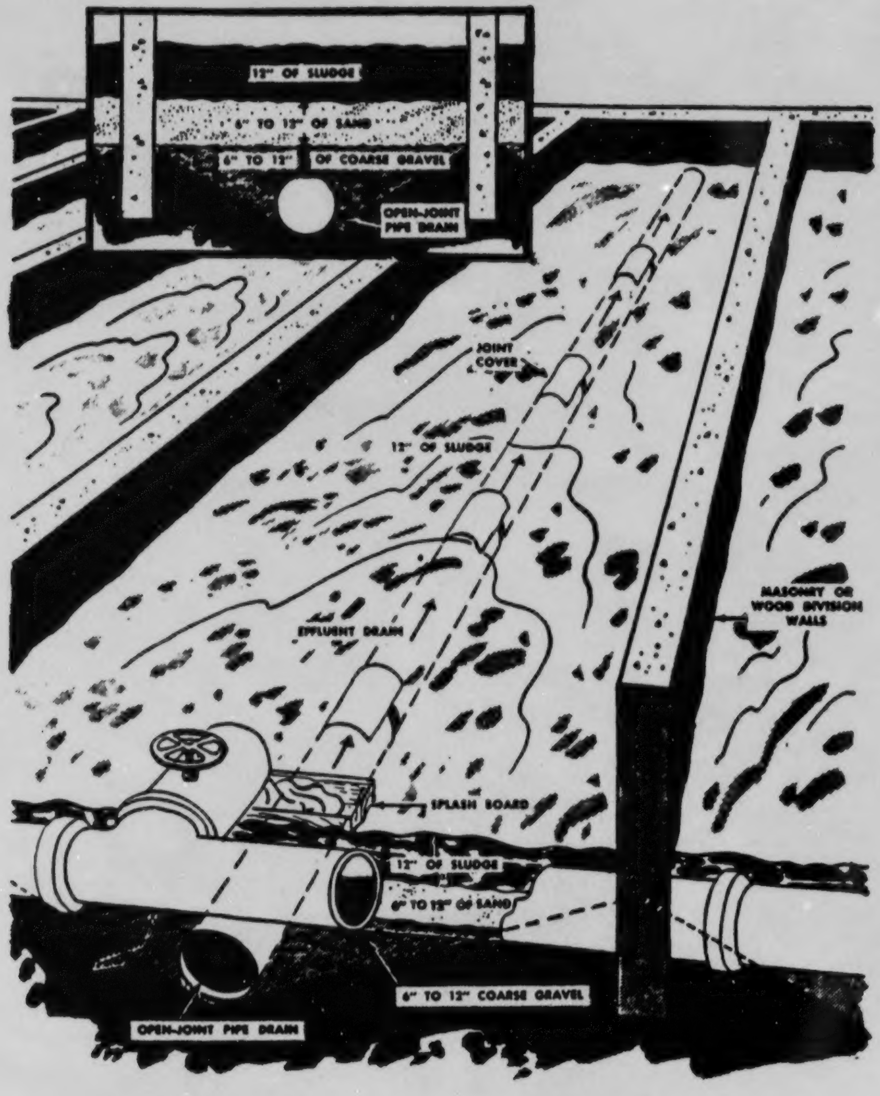

12" OF SLUDGE
6" TO 12" OF SAND
6" TO 12" OF COARSE GRAVEL
OPEN-JOINT PIPE DRAIN
JOINT COVER
12" OF SLUDGE
EFFLUENT DRAIN
MASONRY OR WOOD DIVISION WALLS
SPLASH BOARD
12" OF SLUDGE
6" TO 12" OF SAND
6" TO 12" COARSE GRAVEL
OPEN-JOINT PIPE DRAIN

Figure 13. Sludge Drying Bed

according to the weather and seasons to make the best use of sludge bed capacity. Both digestion and drying are quickened in warm or dry weather, permitting sludge beds to be cleaned and recharged frequently. During cold weather, sludge must be held in digesters or Imhoff tanks until good sludge-drying weather, unless glass-covered beds are available. Storing digested sludge in open tanks or lagoons may be necessary during cold or wet weather, when drying is retarded. Normally, sludge lagooning should not be resorted to unless digester facilities are inadequate to store the sludge produced.

SLUDGE BED PREPARATION. Before sludge is applied to the bed, the sand or other filtering medium must be clean, smooth, and graded slightly away from the point of sludge application to assure uniform depth and free passage of water. Sludge chunks, weeds, and other debris must be removed; a thickness of not less than 4" should always be maintained to assure a clean effluent and to keep solids from entering and settling in the underdrains. Clogged sand surfaces may be remedied by the removal of the top 1/4 to 1" of sand. Splash plates should be provided to prevent incoming sludge from falling directly on the sand surface and disturbing it.

SLUDGE APPLICATION. Excessive filling of sludge bed results in clogging, requiring a longer drying period in which moisture must be removed by evaporation alone. The best filling depth depends on the solid content of the sludge. A depth from 8 to 12 inches is generally recommended. If the bed area is ample, apply sludge and allow it to remain as long as possible to reduce the moisture content. The normally dried cake should be 3 to 4 inches thick, with little sand and easy to handle. If the bed area is limited, sludge must be drawn more often and applied at minimum depths to promote quicker drying. Do not discharge wet sludge on dried or partially dried sludge. Drain sludge lines and flush with a small amount of water or supernatant after each use to prevent sludge from hardening in them. If it is necessary to draw partially digested sludge and fill sludge beds, hydrated lime suspension may be used to arrest decomposition. Add approximately 25 pounds of hydrated lime suspension to each 100 pounds of dry solids in the partially digested sludge. This sludge mixture will be difficult to remove and will dry slowly.

COAGULATION. The addition of floc-forming chemicals that cause sludge particles to adhere with the floc to form small masses of floc and sludge will allow more water to filter out and speed the drying process on sludge beds. This is not a normal procedure but may be used temporarily where it is necessary to speed bed drying to remove sludge from an overloaded digester. The most common coagulating agent is aluminum sulfate or filter alum. Alum in a water solution is mixed with the sludge by siphoning or injecting it into the sludge pipeline to the drying bed as near the digester as possible. As little alum as practicable should be used; 1 to 2 pounds per cubic yard (200 gallons) of sludge are usually required. The proper amount can be determined by mixing known quantities of sludge and alum and observing how the sludge flocculates and separates from the liquid.

REMOVING DRIED SLUDGE. Remove dried sludge when it can be picked up with a fork (not a shovel), without excessive sand sticking to the underside. Moisture content of this sludge usually ranges from 35 to 70%. Dried sludge may be moved from the beds by wheelbarrow, truck, or tractor, but do not allow heavy equipment on the beds unless runways are provided to avoid crushing and clogging the underdrains. Long, covered beds are sometimes equipped with an overhead monorail for easy removal of sludge cakes.

MECHANICAL FILTRATION. Sludge may be preconditioned in preparation for mechanical filtration by washing or diluting the sludge in a tank with two or more volumes of water, mixing, allowing the sludge to settle, and then drawing off the supernatant liquid. This process, which is more effective with digested sludge than with raw sludge, is used to condition sludge for filtration or drying rather than as a separate drying operation. The supernatant is usually returned to the incoming raw sewage.

Sludge must be chemically conditioned for filtration by mechanical filters. Of the numerous types of mechanical filters, the drum type and disk type are most widely used. Filter cloth is the usually filter-medium; it is stretched over copper mesh covering the exterior of a horizontal drum or the leaf of a disk-type filter. This drum revolves continuously and operates automatically through a filtering-drying-discharging cycle. Under the filtering surface, a hollow inner shell forms a compartment subdivided into sections. The inside of each section as it rotates is separately placed under either vacuum or pressure. The filter revolves slowly, partly submerged in a sludge reservoir equipped with an agitator. As the drum passes through the sludge, a vacuum is applied to the inside of the submerged sections to pull a suitable thickness of sludge against the filter cloth. As the drum revolves from the sludge reservoir, the vacuum holds a layer of sludge to the drum and acts as a drying vacuum to draw the liquid into the sections returning the sludge solids in a cake on the filter surface. This filter cake, usually from 1/16 to 1/4", is automatically removed before the drum resubmerges. To help remove the cake from the drum, a slight air pressure is applied to the inside of the section as the cake reaches the removal point, causing it to be lifted or blown off the drum or disk. The broken cake falls into a receptacle or chute or onto a conveyor for transportion to a point for further drying or disposal. The sludge liquor removed is usually returned and mixed with the raw sewage coming into the plant. Both vacuum-producing and air-compressing facilities are required for operating mechanical filters.

SLUDGE DISPOSAL AND UTILIZATION. Well-digested sludge contains about 4 to 10% total solids. The volatile solids content on a dry basis is below 55%, and pH is over 7.0. Poorly digested sludge forms a heavy, sticky, clinging mat over the surface of both sludge and sand in drying beds and retards drying. Undecomposed grease in the sludge clogs the sand. Sludge must come well-digested from digesters and Imhoff tanks for it to dry quickly, completely, and without odors.

Sludge may be utilized for a useful purpose. Sludge drying is usually an additional expense, but it may be justified by local conditions.

DISPOSAL OF DRIED SLUDGE. Remove dried sludge from beds as soon as it can be handled and piled at an accessible place for grinding or hauling. It may be pulverized by a mechanical grinder for easier disposal and/or uniform spreading where it is used as a fertilizer.

Dried digested sludge may be used as a fertilizer. Sewage sludge is not high in nitrogen, phosphates, or potash content, generally having 1.5 to 4.0% nitrogen, 1.5 to 2.5% phosphate, and usually no more than a trace of potash. The principal value of sewage sludge is the humus content which averages from 25 to 35%.

Use of sludge for fertilizer is subject to restrictions. It should not be applied to crops which will be eaten raw. The frequent presence of hookworm eggs in sludge may cause infection where climate and soil favor continued hookworm activity. Digested sludge is particularly suitable for fertilizing vegetation cultivated for dust and erosion control, or for lawns, flower beds, and shrubbery. In many cases, it is possible to sell excess dried sludge locally to nurseries or farmers.

Dry sludge may be used as fill in low areas not subject to heavy traffic. Care should be taken during disposal, because the sludge will not support heavy equipment.

DISPOSAL OF WET SLUDGE. In isolated areas, wet sludge may be discharged directly from digesters to sludge lagoons instead of to drying beds. Lagoons can be constructed as simple earth-walled basins, and underdrains may be provided when lagoons will be reused repeatedly. If only well-digested sludge is discharged into the lagoons, they will be practically odor-free and the liquor from them will not be objectionable. In emergencies, lagoons are sometimes used for digestion of raw or partially digested sludge, in which case odor can be expected. Where large areas are available, lagoons may be used until filled, then abandoned, and new lagoons constructed.

In some instances, particularly where drying bed facilities are deficient, well-digested sludge may be drawn into tank trucks and applied directly to areas being fertilized. Wet sludge is normally applied in quantities of 100 to 400 gallons per acre. Lawns may be sprinkled lightly immediately after an application in order to wash the sludge into the roots of the vegetation.

Wet sludge may also be disposed of by transporting it in tank boats for dumping at sea.

RECORDS. Sludge drying will be reported on the monthly operating log to include the following:

- Total gallons drawn to beds
- Average pH, percent solids, percent volatile solids
- Total cubic yards of dried sludge removed
- Average drying time in days.

Additional information required may be recorded in the remarks column or reverse side of the operating log. The information to be recorded in as follows:

- Date, volume in gallons, and depths in inches of sludge applied to each bed by bed number.
- Results of pH, percent solids, and percent volatile solids of each sludge withdrawal to each bed.
- Date, volume in cubic yards, and disposition of sludge removed from each bed.

SUMMARY

Preliminary treatment includes any treatment or preparation that is done to the raw sewage prior to entry into the settling tank. This can be accomplished by bar screens, grinders, shredders, and chlorination at the pumping station if it is used. Flow metering devices are used within the system to measure influent flow rates and quantities.

Grease and oil may interfere with plant operations such as clogging pumps and filters, and may retard digestion. In some installations, grease and oil are removed in preaeration and vacuum flotation units.

Primary clarifiers are used to digest sludge, remove scum, and heat the sludge. These may be of a rectangular or circular shape.

The Imhoff tank is a two-compartment tank. As anaerobic decomposition takes place in the digestion compartment, the gases produced rise and may be collected for fuel or be allowed to escape to the atmosphere. The separation of the settling and digestion processes permits more efficient settling, keeps sewage in upper compartment fresh, makes digestion more complete, and produces a better effluent.

Separate settling tanks are single-purpose structures for removing settleable solids from the sewage. Sludge deposited in the bottom of these is removed to a separate digestion tank. The settling of solids in separate or plain sedimentation tanks is generally not aided by chemicals or coagulants. These type tanks can be classified according to their methods of sludge removal as, hopper bottom and mechanical sludge collectors. Mechanical-type sludge collectors may be rectangular, circular or square.

The sludge collected in the primary settling tank is usually treated in a digester. The digester changes the sludge into a readily disposed product with minimum interference with other plant operation. The organic matter in sludge is decomposed and stabilized by the action of anaerobic bacteria. (Anaerobic bacteria are able to live in absence of free oxygen.) The final products of digestion are digested sludge, sludge liquor, and gases. The digestion process has three stages: high acid, lesser acid, and fermentation.

Before sludge can be disposed of, it must be suitably dried. The removal of moisture from sludge reduces its volume and changes its characteristics, so that it can be moved with a shovel or garden fork, and can be transported in nonwatertight containers.

The digested sludge is dewatered through use of drying beds or mechanical filtration. The dried sludge may then be disposed of in several ways.

Sludge drying operation is reported on the monthly log.

QUESTIONS

1. Name the types of flow metering devices.
2. What is the recommended length of detention time in the preaeration process?
3. Explain the preaeration process.
4. How is heavy scum disposed of?
5. What is the frequency of sludge removal from primary settling tanks?
6. What is the maximum depth to which hoppers in primary settling tanks may be filled?
7. How do solids get from the settling compartment to the digestion compartment in the Imhoff tank?
8. What two methods may be used to remove digested sludge from the Imhoff tank?
9. What two methods may be used for disposing of skimmings from the Imhoff tank?
10. How often should sludge depth be measured in the Imhoff tank?
11. What are the characteristics of well-digested sludge?
12. What hazards are associated with digester gas?
13. What type of bacteria are in digesters?
14. What are the stages in the digestion of sludge?
15. What is the most satisfactory temperature operating range in digesters?
16. Why is it necessary to thoroughly mix fresh sludge with old sludge in digesters?
17. Name three types of digester tanks.

18. Which type of gas is produced in the largest volume in digesters?

19. What records must be kept on digesters and gas equipment?

20. What is the water content of well-digested sludge?

21. What is the recommended depth of sand and gravel in a sludge drying bed?

22. What are the advantages of covering a sludge drying bed with glass?

23. What is the corrective action for a clogged sand surface in a drying bed?

24. What is the most common coagulating agent used in sewage?

25. How is dried sludge removed from the drying beds?

26. How is sludge conditioned for filtration?

27. In the filtration process, what is used to pull the sludge against the filter cloth?

28. Well-digested sludge contains what percent total solids?

REFERENCES

1. AFM 85-14, Maintenance and Operation of Sewage and Industrial Waste Plants and Systems

2. AFM 88-11, Chapter 3, Sewage Treatment Plants

3. AFP 161-20, Environmental Health Engineering Handbook (Water Pollution)

4. ECI #5503, Volume II, Installations Engineering Technical Supervisor

5. TM 5-665, Operation of Sewerage and Sewage Treatment Facilities

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SECONDARY WASTE TREATMENT

OBJECTIVE

The objective of this study guide is to present those waste treatment units that are considered secondary treatment.

INTRODUCTION

Waste plants discharge large volumes of water. This water normally flows into streams, rivers or lakes. You learned that the effluent from primary treatment still contains a lot of solid content. Secondary treatment is designed to further clean the waste water so the streams will not become polluted.

Let us look at some of the units that make up a secondary treatment system. These units will be covered under the following topics.

- DOSING SIPHON
- TRICKLING FILTER
- OXIDATION PONDS
- ACTIVATED SLUDGE SYSTEM
- CONTACT AERATION

DOSING SIPHON

The dosing siphon is a mechanical device that transfers waste water from the primary treatment system to the secondary system. It is installed in a dosing tank between the primary clarifier and the trickling filter. The dosing tank fills to a preset level; then the dosing siphon automatically siphons the water out.

Operation of Dosing Siphons

Intermittent dosing of the trickling filter is provided by a dosing tank from which fluids are automatically siphoned. A siphon is shown in figure 1. Water will be standing in both the main trap and the blowoff trap. As the liquid runs into the dosing tanks, the level rises, covering the open end of the siphon vent. Then, as the water level rises, air is compressed under the bell. The water level is depressed both in the discharge line and the blowoff trap. This continues until the water level is at the maximum discharge line of the tank, while at the same time, the water under the bell is near the upper end of the discharge pipe. Water level is at the bottom of both blowoff and discharge line. Discharge is now ready and a slight increase of head in the tank causes the water level at the bottom of the blowoff trap to be depressed sufficiently to allow the air pressure to be released with considerable violence up the vent pipe. This sudden release allows water to rush into the discharge pipe. The momentum causes discharge through the siphon and into the distribution system, and the tank is emptied. Emptying continues until the water level in the tank is below the elbow of the siphon vent. This permits air to enter the bell, relieve the vacuum, and stop the discharge. Water has also been running through the blowoff trap so it will be filled when the siphon stops.

TRICKLING FILTER

Description

The trickling filter looks like a swimming pool full of rocks. It can be round in shape or rectangular. The bed of rocks ranges in depth from three to eight feet deep. On top of the rocks is mounted a water sprinkling system. Water is sprayed or sprinkled over the rocks and it trickles downward to an under drain system that carries the water off to another treatment unit.

Purpose

The purpose of trickling filters is to further treat sewage water by letting bacteria, fungi, worms, fly larvae, protozoa and algae break down the remaining waste from primary treatment.

Operation

Settled sewage is applied to the trickling filter in a fine spray. The applied sewage trickles in a thin film over the surfaces of the filtering

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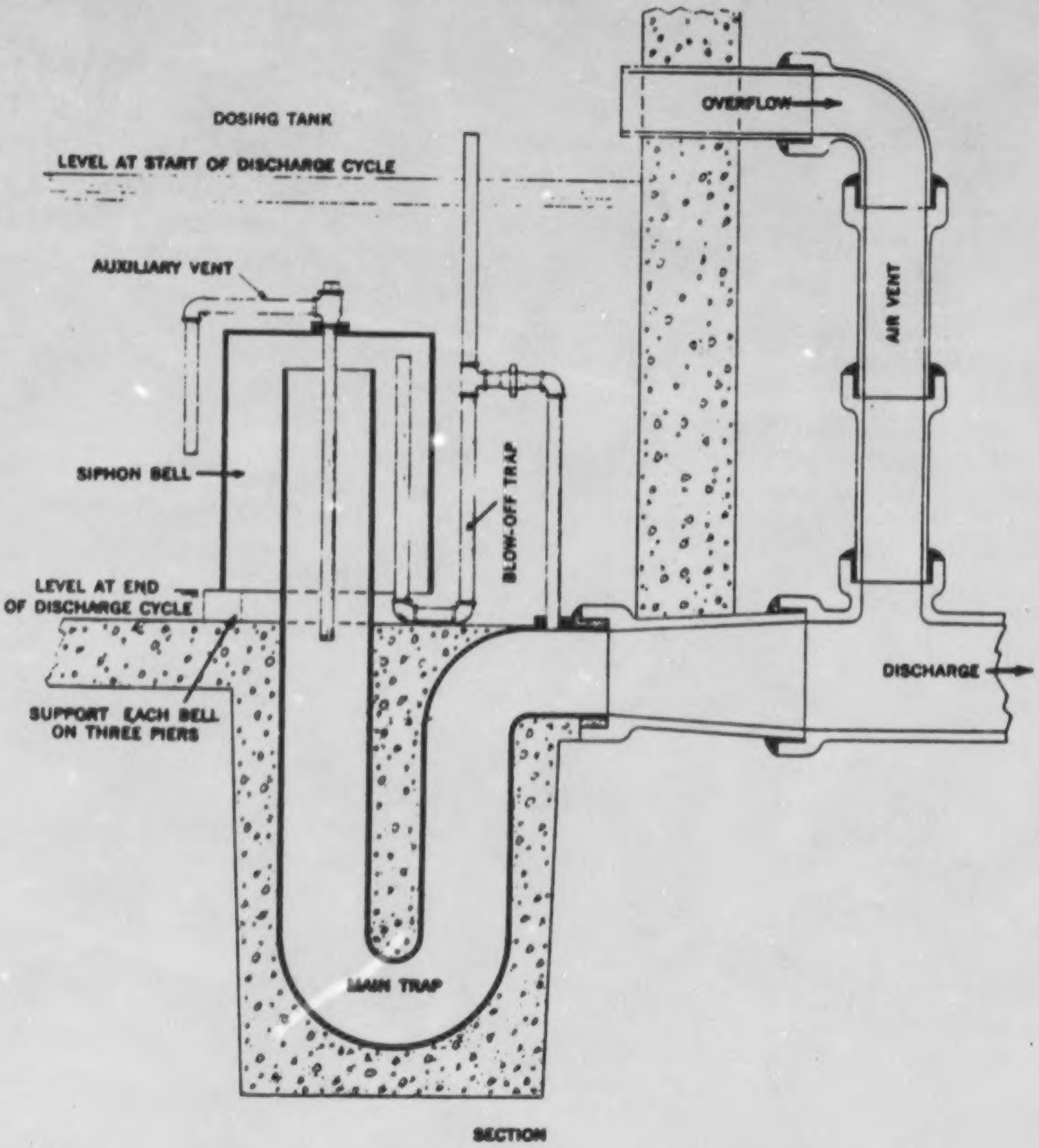

DOSING TANK
LEVEL AT START OF DISCHARGE CYCLE
AUXILIARY VENT
SIPHON BELL
LEVEL AT END OF DISCHARGE CYCLE
SUPPORT EACH BELL ON THREE PIERS
BLOW-OFF TRAP
OVERFLOW
AIR VENT
DISCHARGE
MAIN TRAP
SECTION

Figure 1. Dosing Siphon

medium which become coated with zoogleal film, which contains aerobic bacteria, fungi, worms, fly larvae, protozoa, and algae. A continuous supply of food and oxygen for these organisms is furnished by the applied sewage, which is sprayed on the bed so as to absorb a maximum amount of oxygen. The film over the stones of the filter media removes fine suspended and collodial solids from the sewage and holds them for reduction by the organisms. Since oxygen is present in the filter, a large number of aerobic bacteria will inhabit the film and work on suspended, collodial and dissolved organic solids which have become concentrated in and upon it. This brings about a reduction of B.O.D., ammonia, organic nitrogen, and, especially in the lower portion of the bed, formation of nitrates. The concentration of organic matters in the film from the applied sewage explains why sewage is adequately treated even though only a short period of time is required for it to trickle from the top of the bed to the bottom. A new filter bed must acquire its zoogleal film before it is very efficient. The time required is usually two weeks, although this may be decreased if the filter effluent is recirculated to the filter bed.

Protozoa feed upon bacteria and will reduce the number of coliforms in the applied sewage to about 50 percent in a five foot deep filter. Larger animals, such as worms, may also be present, but the zoogleal-forming bacteria are the most important. The film on the bed becomes heavy and thick at times with dead organic matter which has been worked over by the various organisms. This sloughs off to appear in the effluent as humus - like suspended matter, which still exerts some B.O.D. This sloughing off or unloading is found in all trickling filters. The accumulated material apparently interferes with the aerobic bacteria and reduces the efficiency of the filter. A bed that unloads continuously, thereby keeping retained worn-out film and dead matter to a minimum, usually shows a better all-time efficiency than a filter that sloughs off periodically. A thin transparent film upon the filter media indicates favorable condition. The unloading characteristics of trickling filters make it necessary to give final sedimentation to the effluent.

Bacterial and other organisms are continually active when food and oxygen are available and do not need any time for rest. With substrates encountered in sewage treatment, the more food that is available, the more active they will be, and only stop when the food supply stops. Thus, the upper portions of a trickling filter are more active than the lower portions in removal of B.O.D. This explains why, when trickling filters are operated in series, the secondary filter operates less efficiently than the primary filter.

Loading of Filters

Filter loading is usually expressed as either the volume of sewage applied per unit of filter surface, or the strength of sewage in terms of quantity of B.O.D. applied per unit of filter volume.

Volumetric loading is expressed as millions of gallons per acre day (m.g.p.a.d.). To determine the volumetric loading, the average flow in m.g.d. to the filter, including any recirculated effluent, is divided by the filter area in acres.

B.O.D. loading is expressed as pounds of B.O.D. applied per day per acre foot. (Acres times depth in feet.) It is determined by multiplying the average B.O.D. (in p.p.m.) of the primary effluent by the average flor (in m.g.d.) and by 8.34 to obtain pounds of B.O.D. per day, and dividing this by the acre-feet of filter area. If filter or final tank effluent, other than normal amounts of final tank sludge, is returned through the primary settling tank, the recirculating B.O.D. load exaggerates the loading as calculated in this manner. In such cases B.O.D. loading is based on the quantity and B.O.D. of the raw sewage, less an assumed 35 percent B.O.D. removal in the primary settling tank. High capacity filter, B.O.D. loading is sometimes expressed as pounds per cubic yard. To convert this to pounds per acre-foot, multiply by 1, 613. Table 1 illustrates some types of filter loading.

Efficiency of Filters

The efficiency of filter operation, assuming the filter is not overloaded, depends on distribution, ventilation, filter media and temperature.

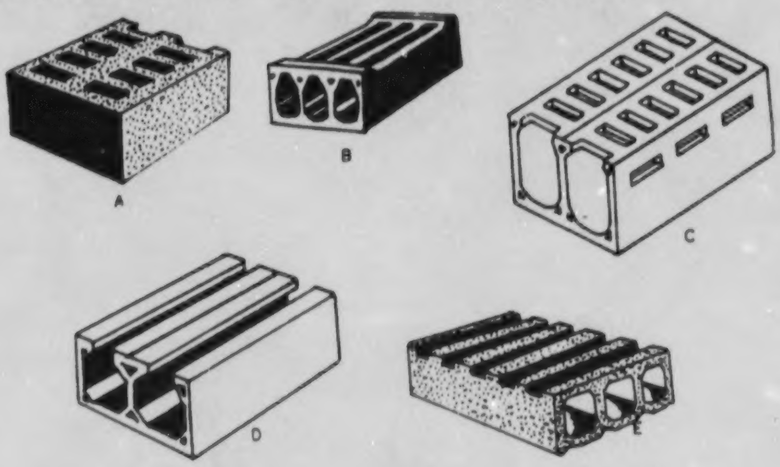
Sewage must be distributed evenly to make effective use of the whole surface. Uniform distribution through fixed nozzles is provided by proper dosing of the dosing chamber. As head decreases, the circle of application becomes smaller. Rotary distributors have a larger number of orifices or nozzles at the outer ends of the arms than the inner ends to cover the increased area of the larger circle. Revolving disk distributors have vanes of several sizes to give uniform application over the entire filter.

FILTER TYPES	LOADING Volumetric (m.g.p.a.d.)	 BOD lb per acre ft
Standard Rate (Low Rate)		
Normal Design	Approx 2	600
Highly Loaded	2 to 10	600 to 1,500
High Rate		
Normal Design	10 to 60*	3,000
Low Loading	10 to 60	1,500 to 3,000
High Loading	10 to 60*	3,000 to 5,000
Roughing (followed by additional secondary treatment)	10 to 60*	3,000 to 12,000

*May be above m.g.p.a.d. in some cases

Table 1. Filter Loading by Types

The spaces in the filter media must be kept open to provide air circulation. Natural air movement is up through the filter in cold weather and down in warm weather because of temperature difference between air and sewage. Filter underdrains must be ample in size, kept open, and their outlets unobstructed to allow passage of air (see figure 2). Forced ventilation of beds by means of blowers is sometimes provided.



A, ARMCRE BLOCK; B, NATCO TILE; C, ARMCRE BLOCK WITH LATERAL VENTILATING SLOTS; D, METRO MONOUNIT TYPE; E, CANNELTON BLOCK.

Figure 2. Blocks Used in Underdrain System of Trickling Filters

The filter media must be hard stone, free from dust, dirt or other foreign material, and uniform in size (two to four inches) throughout the filter to avoid dense spots that may cause ponding.

Filters operate best during warm weather. Winter conditions in northern climates may reduce efficiency as much as 50 percent.

Types of Filters

LOW RATE FILTERS. Standard or low-rate filters may be rectangular with fixed nozzles, as shown in figure 3, or circular with rotary distributors as shown in figure 4. In either case, intermittent dosing is provided by a dosing tank with automatic siphon or by direct pumping.

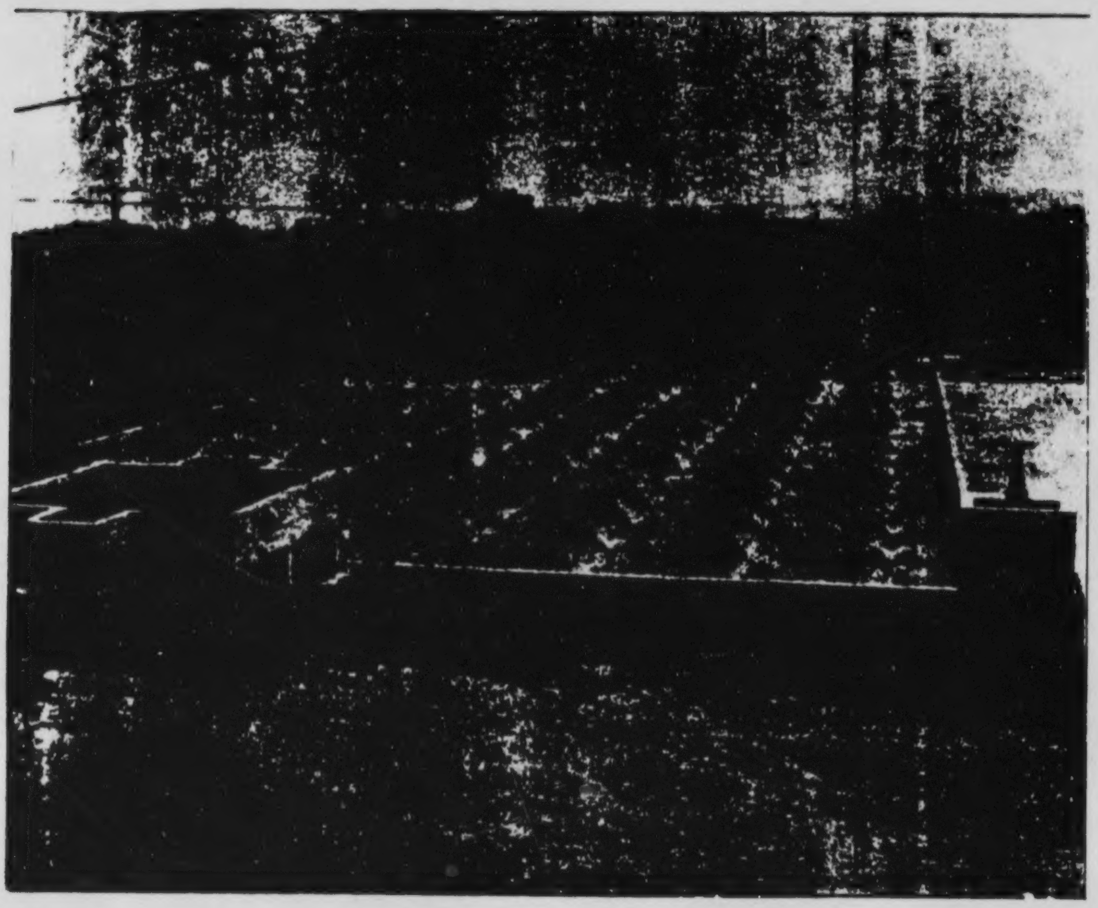


Figure 3. Standard Filter with Fixed Nozzles

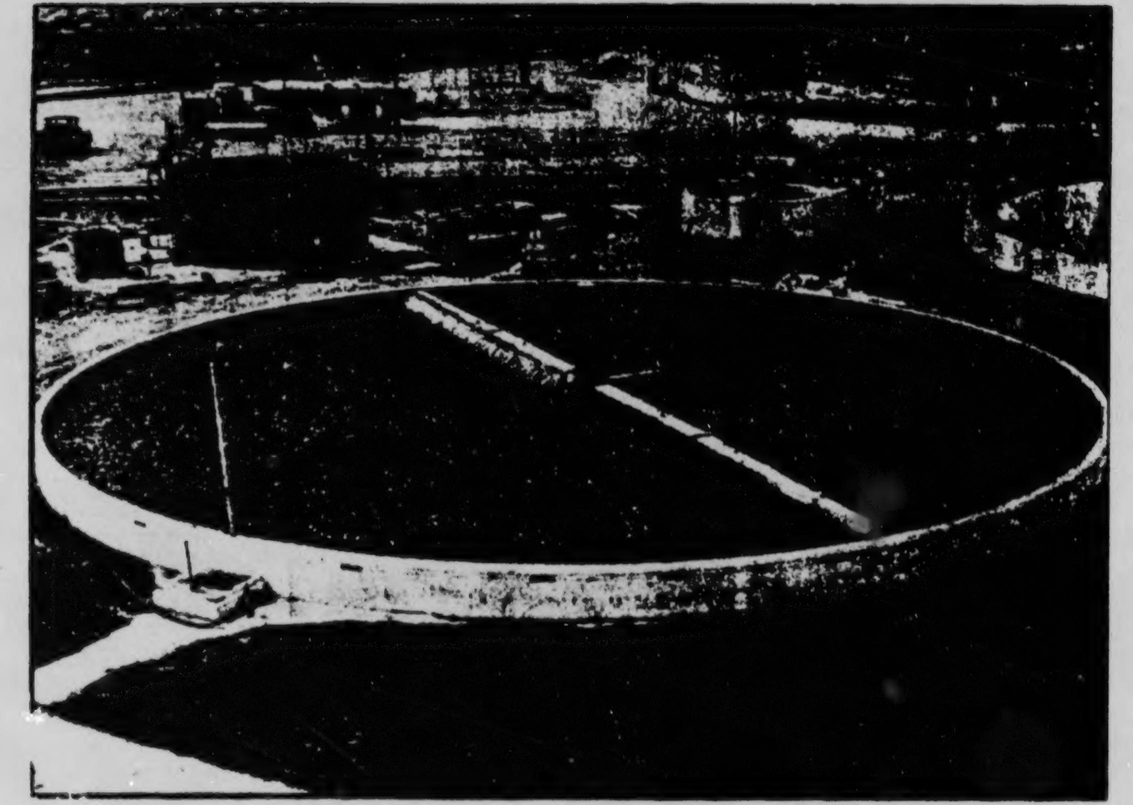


Figure 4. High Rate Filter with Rotary Distributor

The standard rate filter, usually unloads during fall and spring. When a change in temperature or heavy flow of influent causes the beds to slough off its growth of organisms and dead matter, the filter effluent becomes turbid and frequently carries off large masses of worms normally present in the filter. The solids in this effluent are removed by final settling.

HIGH RATE FILTERS. High rate trickling filters are usually circular in shape to accommodate the rotary distribution, as shown in figure 4 which is more satisfactory for the high variations in flow than the fixed-nozzle sprays. The filter stones are generally about one inch larger in size than those used for standard or low-rate filters. Sewage is applied continuously, and a portion of the effluent from the secondary settling tanks is usually recirculated and reapplied to the filter with the primary settling tank effluent.

Advantages of the high-rate filter are slightly lower initial cost, smaller plant area required, freedom from filter flies, and reduced odor problems. Some of the disadvantages are that operation is much more sensitive, the filter is unable to handle wide ranges of loading, the resulting sludge has a high water content and is more putrescible, and the degree of purification is lower unless recirculation is employed, which increases the operating cost.

In high-rate filters, sewage that has already passed through the filter is recirculated, either continuously or at times of low flow of raw sewage. By this means, a greater volume is applied and sewage strength is reduced making the volume of flow on the bed more constant than for standard-rate filters. The heavy application of sewage causes continuous unloading and reduces film thickness, with the following effects: reduction of fly-breeding by washing out more larvae, preventing odors by freshening the sewage, more uniform operation, the seeding of applied sewage with active organisms and enzymes resulting in more efficient treatment with better utilization of the depth of the filter. Solids are not retained as long as in standard-rate filters, so they are less stable and continue to exert a considerable oxygen demand in settling tanks receiving filter effluent. Likewise, the solids have considerable oxygen demand and continue clarification and B.O.D. removal in settling tanks as long as aerobic conditions are maintained. Nitrification is negligible with B.O.D. loading in excess of 2,000 pounds per acre-foot. Settling tanks, including primary tanks if filter effluent is returned through them, are integral parts of high rate filter treatment. There are three types of high rate filters, the Aero-filter, Bio-filter and Accelo-filter.

Aero-Filter. The Aero-filter is designed to dose the entire filter bed surface continuously and at a uniform rate. The beds are usually six to eight feet deep, with the filter media from two to four inches in diameter. Recirculation, which is not an important element of the process, is usually used only during periods of low flow to maintain the minimum rate of application. A continuous trickling of the sewage over the filter media, with maximum contact and aeration, is essential. For beds under 34 feet in diameter, a motor driven rotating disk provides distribution; for larger beds, rotary distributors with four to ten branched arms are used. Figure 5 illustrates the single stage aero-filter. Special nozzles discharge sewage in a rain-like spray. A dosage rate in excess of ten m.g.d. is maintained. Adequate ventilation of the filter bed is essential for oxidizing the sewage; forced air may be required when the temperatures of air and applied sewage are within ten degrees F of each other. If blowers are provided to force air through the filter, all openings to air at the filter base must be sealed and operation must be continuous. These plants may have single or two-stage treatment as shown in figure 6.

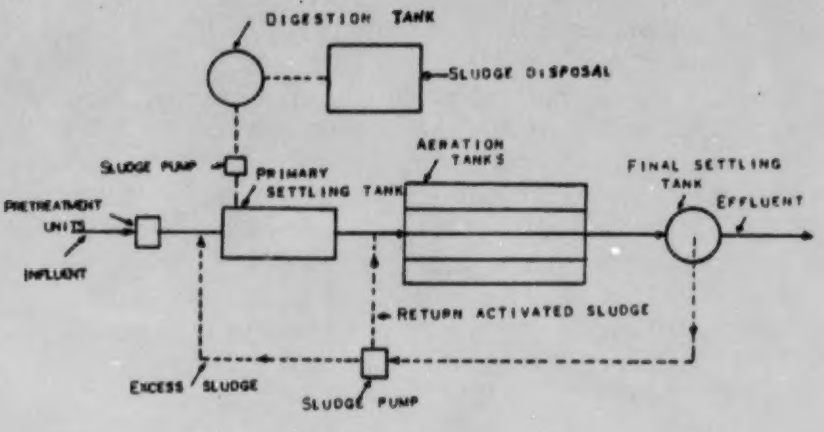
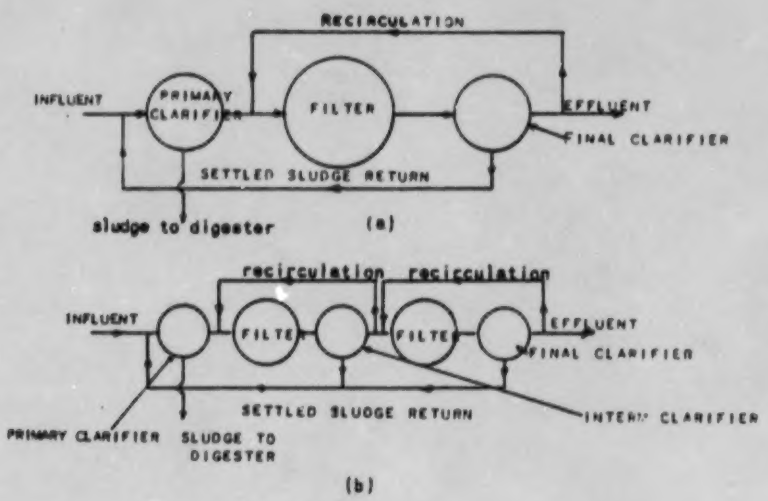

DIGESTION TANK
SLUDGE DISPOSAL
SLUDGE PUMP
PRIMARY SETTLING TANK
AERATION TANKS
FINAL SETTLING TANK
EFFLUENT
PRETREATMENT UNITS
INFLUENT
RETURN ACTIVATED SLUDGE
EXCESS SLUDGE
SLUDGE PUMP

Figure 5. Single-stage Aero-filter and High-rate Two Stage Filter

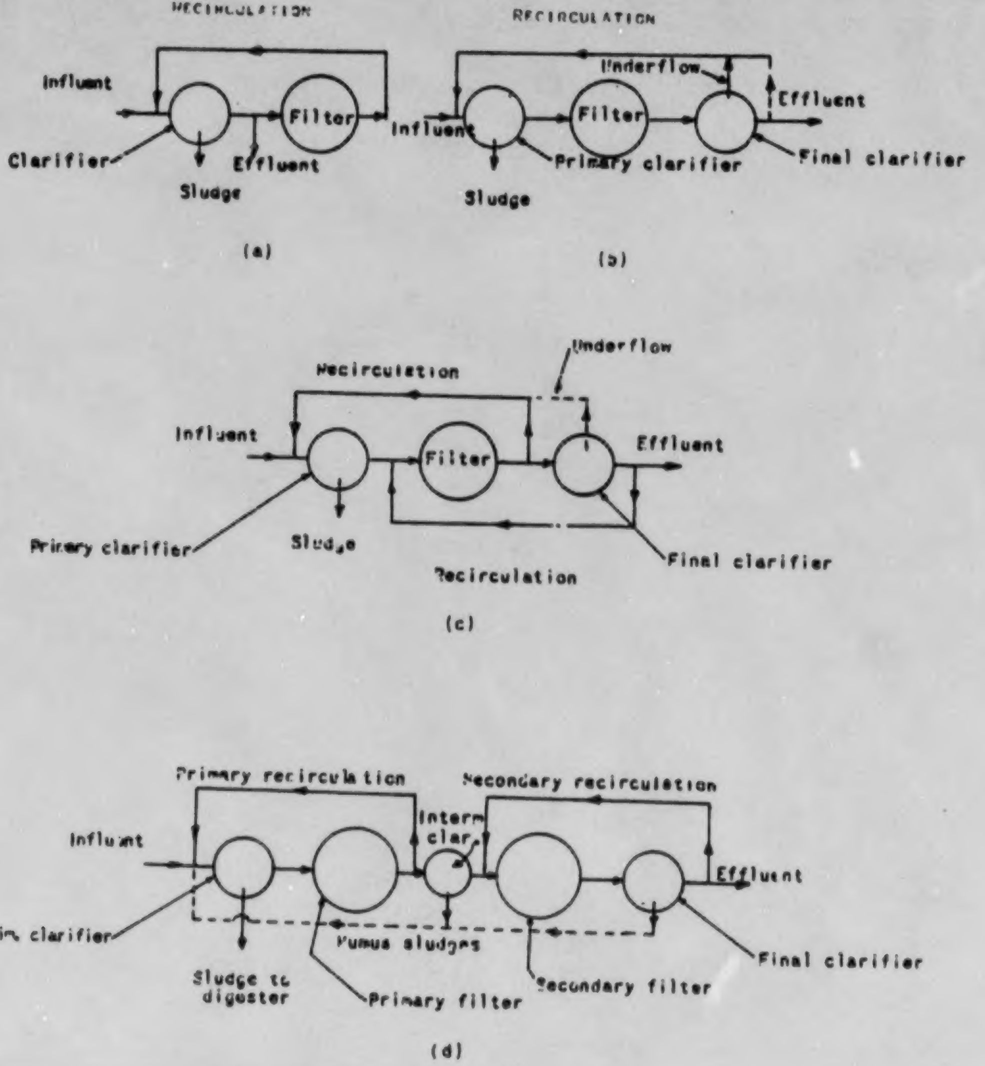

RECIRCULATION
INFLUENT
PRIMARY CLARIFIER
FILTER
EFFLUENT
FINAL CLARIFIER
SETTLED SLUDGE RETURN
sludge to digester
(a)
recirculation
recirculation
INFLUENT
FILTE
FILTE
EFFLUENT
FINAL CLARIFIER
SETTLED SLUDGE RETURN
INTERIM CLARIFIER
PRIMARY CLARIFIER
SLUDGE TO DIGESTER
(b)

(a) Single-stage plant. (b) Two-stage plant.

Figure 6. Flow Diagram of Aero-filter Plants

Bio-filters. Bio-filters combine the use of a clarifier and high-rate trickling filter with filter discharge material returned to the clarifier.

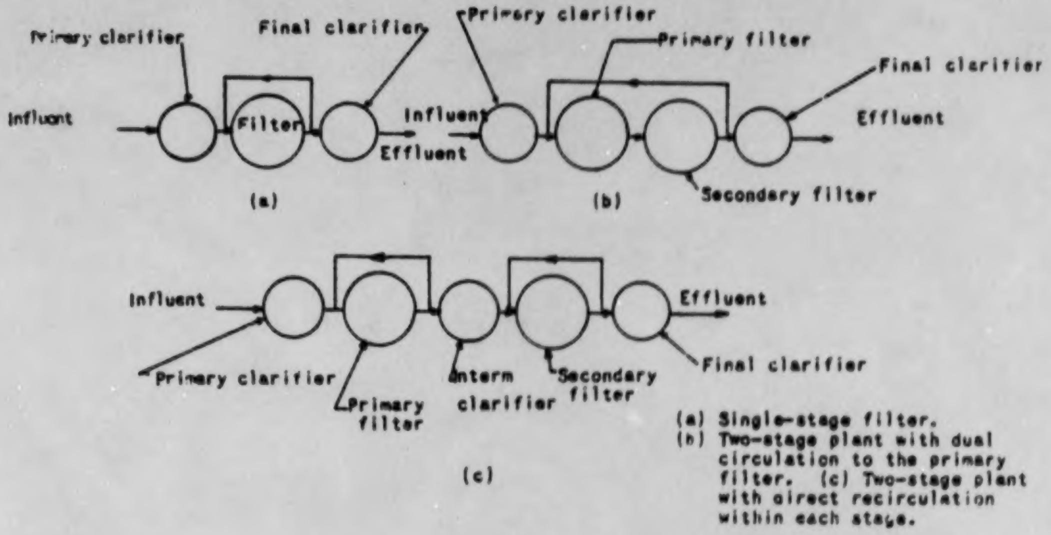
The recycled filter discharge material may consist merely of filter, effluent or of flow from a secondary clarifier following the filter. (See figure 7.)


Recirculation
Influent
Filter
Clarifier
Sludge
Effluent
(a)
Recirculation
Underflow
Effluent
Influent
Filter
Primary clarifier
Final clarifier
Sludge
(b)
Underflow
Recirculation
Influent
Filter
Effluent
Primary clarifier
Sludge
Final clarifier
Recirculation
(c)
Primary recirculation
Secondary recirculation
Influent
Interm clar.
Effluent
Prim. clarifier
Humus sludges
Final clarifier
Sludge to digester
Primary filter
Secondary filter
(d)

(a) Single-stage intermediate treatment.
(b) Single-stage complete treatment.
(c) Single-stage complete treatment with dual recirculation.
(d) Two-stage treatment. Intermediate clarifier is sometimes omitted.

Figure 7. Bio-Filter Flow Diagrams

Accelo-Filter. The Accelo-filter system includes recirculation of unsettled effluent from the filter back to the inlet of the filter distributor as shown by the flow diagram of figure 8. It is used for both low-rate and high rate filters. The principle claimed for this system is that the direct return of filter effluent intensifies biological oxidation.


Primary clarifier
Final clarifier
Influent
Filter
Effluent
(a)
Primary clarifier
Primary filter
Final clarifier
Influent
Effluent
Secondary filter
(b)
Influent
Effluent
Primary clarifier
Primary filter
Interm clarifier
Secondary filter
Final clarifier
(c)

(a) Single-stage filter. (b) Two-stage plant with dual circulation to the primary filter. (c) Two-stage plant with direct recirculation within each stage.

Figure 8. Flow Diagram of Accelo-Filter

Operation of Filters and Appurtenances

CONTROL OF PONDING. Ponding is caused by dense spots in the bed that stop flow. The condition may result from the application of an excessive volume of sewage to the filter; a large amount of suspended solids or grease in the influent; filter materials that are crumbled, dirty, or too small; prolific growth of fungi, algae, and other animal and plant forms filling the voids between stones; or poor ventilation. Ponding caused by plugging of filters may be reduced or eliminated by one or more of the following: (1) Flushing the surface with a fire hose; (2) Raking or forking the surface stone; (3) Stopping the distributor over the plugged area and allowing the sewage flow to wash down the growth; (4) Punching holes in the top layer of stone with an iron bar; (5) Applying chlorine or chlorinated lime, up to 5 p.p.m. residual, to the filter influent for two to four hours at weekly intervals. This should be done at night when sewage flow and chlorine demand are low. (6) Flooding the filter for 12 to 24 hours, if possible, every 7 to 14 days; (7) Allowing the growth to dry by resting the filter for 12 to 48 hours if other units are available.

CONTROL OF FILTER FLIES. The film on standard rate filter bed stone frequently becomes infested by filter flies. The Psychoda alternata, or filterfly, is a nuisance to plant operators and nearby residents. Heavy infestation is caused by high temperatures and thick growth on stones. Filter flies can be eliminated by flooding the filter 12 to 24 hours every two weeks, by heavy doses, 6 to 15 p.p.m. of chlorine at the filter influent or dosing tank, or by changing to high rate operation.

FILTER MEDIA AND UNDERDRAINS. Keep the filter surface free from leaves and twigs. Any small rock or sand particles or other accumulations must be washed out of the filter underdrains and removed from the collection channels to prevent their discharge to settling tanks where they may plug sludge lines. Keep the underdrains and channels open to ventilate the filter. In winter, the filter surface must be kept sufficiently free from snow and ice to permit proper operation of the rotary distributor. Remove disintegrated filter stone and replace with sound stone.

ODOR CONTROL. Odors caused by decomposition of organic matter may be reduced or controlled by the following means: (1) recirculating final effluent to add dissolved oxygen; (2) reducing primary tank detention periods by taking one or more tanks of out of service, if the detention period exceeds three hours; (3) chlorinating filter influent with dosages up to 5 p.p.m.; (4) the application of chlorine or copper sulfate to the raw sewage at the upper ends of the system is helpful in preventing septic sewage; and, (5) flushing sewers periodically is also helpful in delivering fresher sewage to the treatment plant, thereby assisting in odor control.

WINTER OPERATION. In many cases, operation of trickling filters during cold weather causes little difficulty. In extremely cold climates, however, it will be necessary to take precautions to avoid damage to equipment or interruption of the operation. In the case of rotary distributors, the drain valve in the distributor base is usually opened slightly to drain and prevent freezing in the distributor arms. Use of recirculation to minimize freezing at the filter by cutting down the time of the dosing cycle during low-flow periods is also practiced. To minimize freezing, dosing tanks are sometimes covered with planking and insulated with straw.

SLUDGE REMOVAL. Sludge from settling tanks following high-rate filters becomes septic more rapidly than that from standard-rate filters and must be removed at least once each shift or oftener as necessary. If centrifugal pumps are used, recirculation to the primary settling tanks should be from the bottom of the tanks or the sludge removal pipe to give continuous removal of sludge.

OXIDATION PONDS

Oxidation ponds sometimes called lagoons, holding or evaporating ponds, or percolation beds, under certain conditions offer economical sewage treatment and disposal with a minimum of initial materials.

An oxidation pond is a shallow basin in which the sewage or industrial waste is held for a period of time, such that some desired degree of stabilization occurs. There may or may not be an effluent from an oxidation pond. Some are so designed that evaporation and percolation proceed at a rate sufficient to keep all the waste within the oxidation pond; others are designed for continuous effluent flow. Oxidation ponds have banked edges of sufficient thickness to contain the waste waters. These banks have an inside slope of about four to one. To reduce the erosion effects of any wave action due to winds, the entire area within the oxidation pond is usually stripped of vegetation, and the tops and outer sides of the retaining banks are grassed.

Oxidation ponds may be constructed so that the waste waters are from 3 - 5 feet deep; usually, they are not constructed over three feet deep. When the wind is strong enough to prevent surface scum, inlet or effluent baffles may not be required. Distribution baffles are shallow so water velocity under them is not rapid enough to scour the pond bottom. It is recommended that the sewage should be discharged into the center of the oxidation pond slightly above bottom elevation. Some structures carry effluent from one oxidation pond to another. These usually provide some turbulence and aeration. Some ponds are designed to provide a minimum of 30 days detention of the average daily flow. In determining this detention period, only the top two feet of water in ponds under ten acres in area and only the top three feet in ponds over 20 acres in area are considered.

In oxidation ponds, treatment is accomplished by nature with very little assistance from man. If sufficient time and sunshine are provided, bacteria and algae, with the help of occasional wind action, stabilize the organic matter in the waste water. (See figure 9.) Where the velocity of flow is reduced on entering the oxidation pond, suspended and setteable soilds will be deposited. These plus the dissolved organic matter are the food stuff for the forces of nature.

Oxygen is supplied on the surface and stirred in by wind action. Additional oxygen is made available by green plants; therefore, the need for shallow oxidation ponds so that these plants may receive the sunlight they require. Bacterial decomposition of the deposited or dissolved solids furnishes carbon dioxide.

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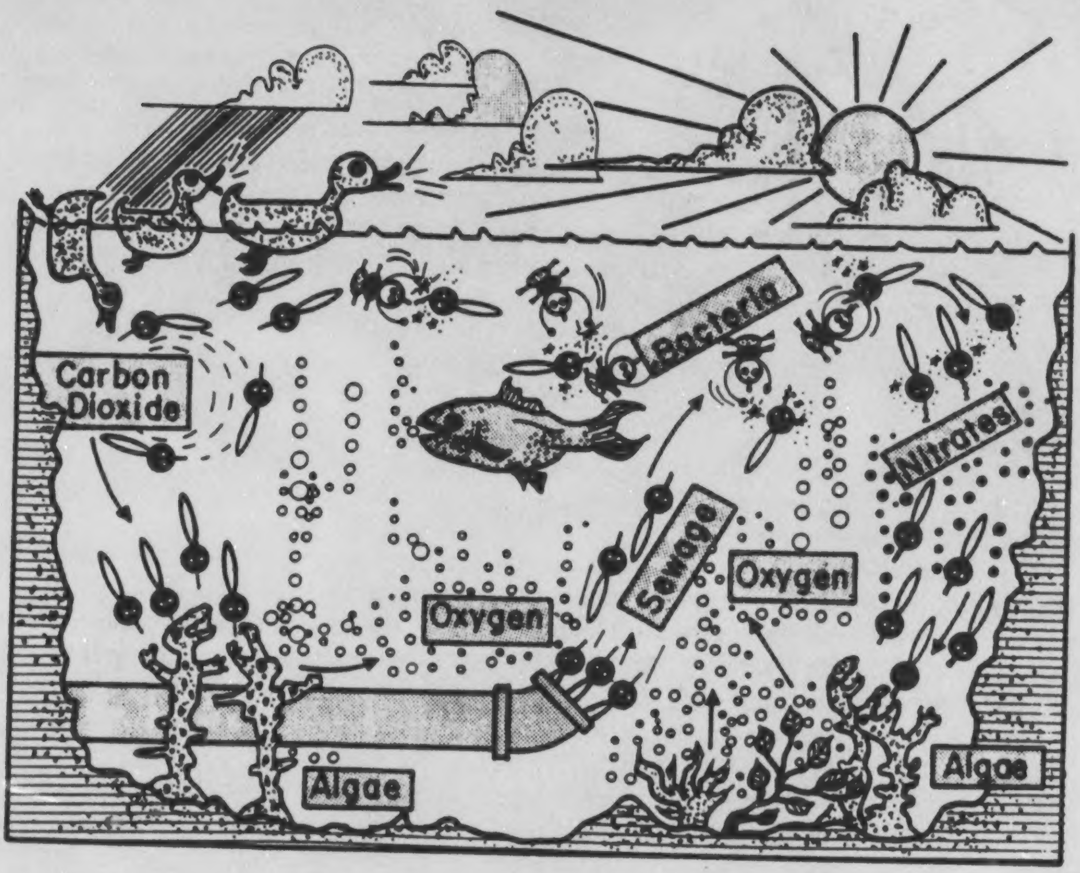

Carbon Dioxide
Bacteria
Nitrates
Sewage
Oxygen
Oxygen
Algae
Algae

Figure 9. Waste Treatment in Oxidation Ponds

Other nutrients, such as nitrogen and phosphorus, are also available from the sewage.

Several other factors should be considered in using oxidation ponds to treat sewage wastes. Due to the wide shallow area exposed to the atmosphere, evaporation of water will take place. Further, some percolation of water into the ground will also occur. Both of these tend to reduce the volume of waste to be disposed. Consequently, the use of oxidation ponds is most efficient where these two factors are high.

There is the possibility of contamination of ground water by percolation of oxidation pond waters. Therefore, an investigation should be performed before adopting oxidation ponds for waste treatment. However, in passing through an oxidation pond, a certain amount of bacterial reduction occurs. These reductions in coliform organisms are primarily due to the action of natural enemies on these bacteria.

Oxidation ponds may be designed to discharge a continuous effluent just as a sewage plant does, or if sufficient areas is available, to rely upon evaporation and percolation to the extent that no effluent or discharge occurs. When an effluent is discharged, it will usually be lower in B.O.D. and will be supersaturated with dissolved oxygen.

This state of supersaturation is due to the action of algae in the oxidation ponds. Algae are simple one celled green plants that live in streams. They and the bacteria do the major part of the work in oxidation ponds. The bacteria in the oxidation ponds break down the organic carbon materials in the sewage to carbon dioxide. The algae take the carbon dioxide into their systems and give off oxygen.

The oxidation of sewage is conducted in many ways for various purposes. It can be used on industrial or domestic sewage. It has been used for partial or complete treatment. Due to the location and design of various bases, the adaptability of oxidation ponds will vary. Sewage plant effluent may be discharged to oxidation ponds in favorable locations such as desert or isolated areas, and where ample land is available and the climate is dry and warm.

Treatment

To use oxidation ponds for treatment and disposal, certain conditions are necessary for proper operation.

MINIMUM PRETREATMENT. Primary-settling is the minimum treatment given sewage before it is put into the lagoons. Otherwise, except under unusual conditions, sludge deposits build up in the influent section of the lagoons, not only causing septic conditions during digestion but also making periodic cleaning of the inlet lagoon necessary.

PERCOLATION. When ponds are first operated or if they are located above coarse sand or gravel formations, much sewage is lost through percolation into the soil. Unless the formation under the pond is generally porous, this condition generally lasts only for a short time. The floor clogs rapidly with sediment, greatly reducing or eliminating completely the sewage flow into the ground.

EVAPORATION. Evaporation may cause considerable sewage loss, depending on the surface area of the pond. In some dry areas such loss equals the entire sewage flow.

SETTLING. Additional suspended solids settle out while the effluent remains in the ponds, thus improving the quality of the effluent.

BIOLOGICAL ACTION. Biological life developed in the lagoons uses the organic and mineral matter in the sewage for food to produce more stable products. These products often stimulate abundant growth of algae and other vegetation. Solution of oxygen from the atmosphere, and ability of vegetation to produce oxygen under sunlight help maintain aerobic lagoons. In a properly constructed system, aerobic conditions establish themselves after a short detention period. The lagoons develop an odor similar to fresh-water ponds in wooded areas. During cold or cloudy weather, treatment becomes much less effective because algae oxygen production is retarded.

Operation

When the weather is clear and warm and the pond system is operated normally and in series, the quality of successive effluents improves as it passes between ponds. Dissolved oxygen appears and often increases to the supersaturation point; the pH increases as the sewage flows from one pond to the next until the effluent is definitely alkaline and the B.O.D. and suspended solids decrease. Operation and maintenance procedures are simple and are generally as follows.

WALLS. Protect the inside of wall surfaces from collapse or wave erosion by adequate width and height of fill.

MOSQUITO CONTROL. Control mosquito breeding by keeping the shores clean and by alternately raising and lowering the water level about six inches every ten days during breeding season.

SLUDGE. Make sure that no raw or digested sludge or supernatant liauor is discharged into the ponds.

THE ACTIVATED SLUDGE PROCESS

The activated sludge process is a method that employs a sludge which by aeration and agitation has become flocculent and has accumulated a population of aerobic bacteria. This is added to sewage and the mixture is agitated in the presence of oxygen. The mixed liquor is then settled in a secondary or final settling tank. The clear liquid is emptied into a stream or upon the ground. Part of the sludge is recirculated through the aeration tank and part of the sludge that is not needed for the desired action in the aeration tank is sent to the digester. This is illustrated in figure 10.

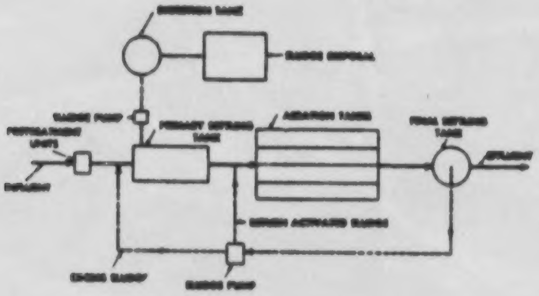


Figure 10. Flow Diagram of Activated Sludge Process

Activated sludge appears as a light to dark brown floc and settles rapidly. The jelly-like portion of the sludge contains many filamentous and unicellular bacteria and algae. Upon this jelly-like mass numerous protozoa and some metazoa attach themselves and feed upon the organic matter contained in the sewage. This matter is ingested and assimilated by the protozoa, and their bodies are an end product of the sludge. The zoogleal-forming bacteria are present and important. Some theories state there must be a proper relationship between the bacteria and protozoa, while other theories hold that the number and species of protozoa indicate the condition of the sludge. In any case, the sludge must have a supply of nutrient to support its living organisms. Dissolved oxygen from the sewage, sludge mixture, sludge and sewage must be thoroughly agitated during the aeration period. Oxygen may be obtained through diffused air or at the surface of the tank.

During the aeration of the mixed liquor, adsorption of solids and biological oxidation of the adsorbed material takes place. Usually 15 to 45 minutes of contact with the sludge is required for the adsorption of solids before biological oxidation begins. The highest rate of oxidation usually occurs when the recirculated sludge first comes into contact with sewage falling off gradually for two to five hours, then continuing for a long period at a more or less uniform rate. Proper functioning of a plant requires a balance between the two functions. If biological action proceeds too rapidly, the sludge becomes very dense, but very small particles are broken off and do not settle to give a clear effluent. If biological action lags behind, the floc becomes very bulky and light, and will not settle in the final settling tank, and the effluent will not be well clarified. But with good operation, it will balance the two processes.

BIOLOGICAL ACTION. When sewage is agitated continuously in the presence of oxygen, an active biological material known as activated sludge, is developed. This brownish floclike substance is composed of numerous organisms, including protozoa, in a mixture of organic solids in various stages of decomposition. Activated sludge absorbs dissolved organic material, including ammonia; it has an agglutinating or flocculating property which frees sewage from its dissolved and suspended impurities. Some materials in sewage are consumed by the organism but their most important function may be the production of complex chemical substances called enzymes which react rapidly to change objectionable matter to stable substances.

FLOW PROGRESS. A flow diagram of the activated sludge process is shown in figure 10. After receiving primary settling, sewage is mixed with activated sludge to form mixed liquor. The mixed liquor then received prolonged aeration in an aeration tank and is conveyed to the final settling tank from which clear supernatant liquid is usually discharged without further treatment. The sludge collected at the tank's bottom is returned, all or in part, to the influent end of the aeration tank and mixed with incoming settled sewage to continue the purification process. Excess sludge is usually pumped to the plant influent and is resettled with the primary sludge to concentrate it.

Types of Aerators

The basic factor in the activated sludge process is aeration, which is necessary to supply an adequate supply of oxygen to keep it biologically active. There are two general aeration methods.

DIFFUSED AIR. In diffused air plants, aeration is accomplished by compressed air released at the bottom of the aeration tank, passing upward through the tank contents. Aeration tanks are designed and diffused equipment is usually located so as to give a spiral motion to the mixed liquor. Methods include placing diffused plates on the floor of the tank adjacent to a wall over diffuser-plate boxes (see figure 11); inserting diffuser tubes into the sides of a fixed air pipe along one side of the tank; attaching diffuser tube assemblies to movable pipes (swing diffusers) by which the tube assemblies may be lifted out of the tank for cleaning (see figure 12). The principal components of the swing diffuser are shown in figure 13.

In diffused-air plants, air discharged through the diffuser should be controlled at both the blower and down pipes. With this control, air input can be fitted to the changing demands of sewage strength. About 95 to 98 percent of the air keeps the tank contents in motion, mixing and causing solids to form floc; the rest of the air is used to supply the oxygen required for oxidation and stabilization. One type of blower used for providing air to diffusers is shown in figure 14.

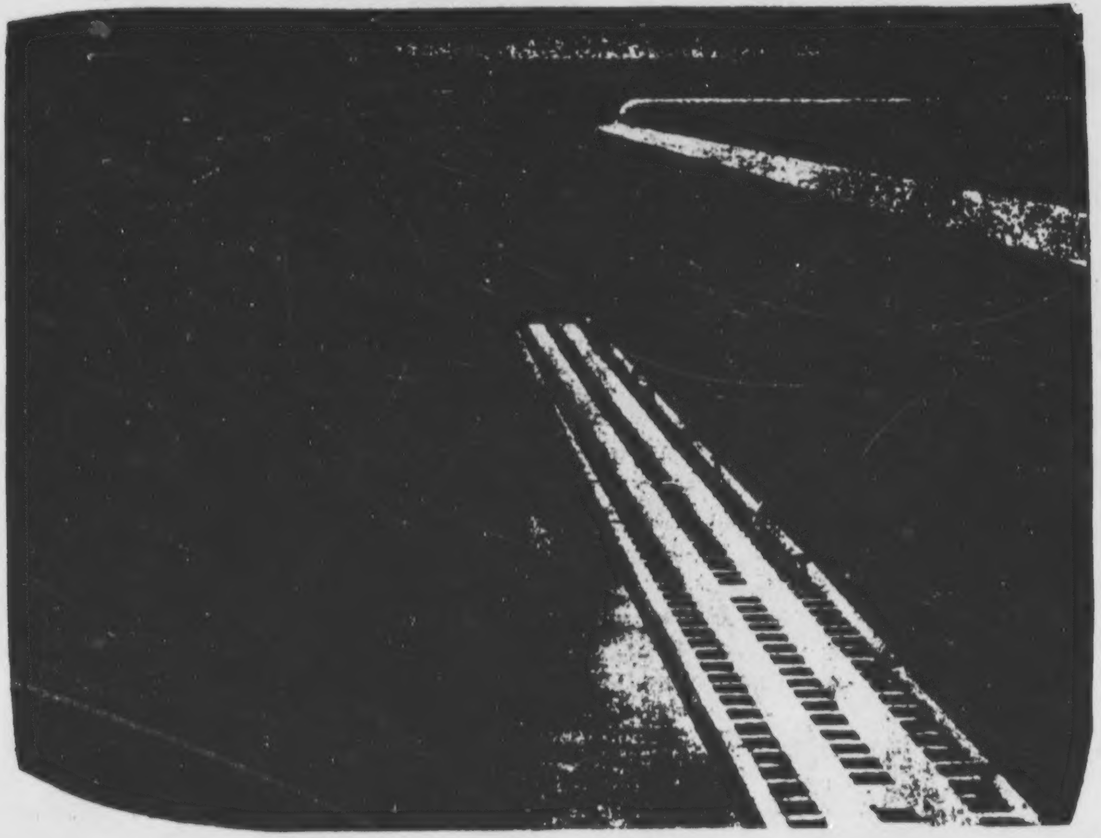


Figure 11. Diffuser Plates and Air Piping in a Spiral-Flow Aeration Tank

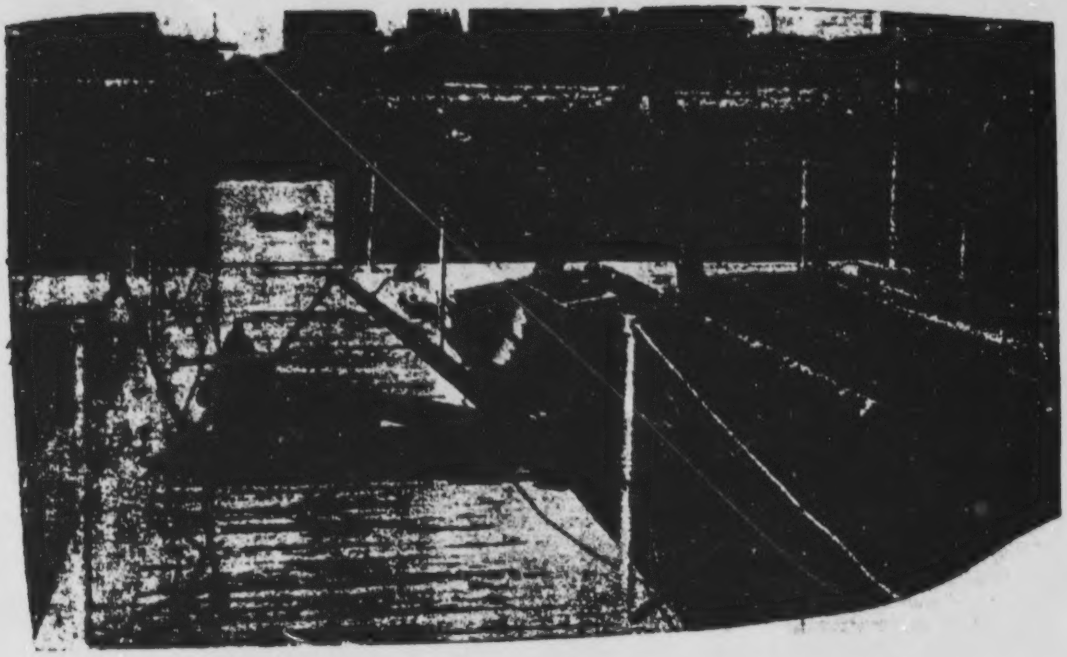


Figure 12. Swing Diffuser in Raised Position for Servicing

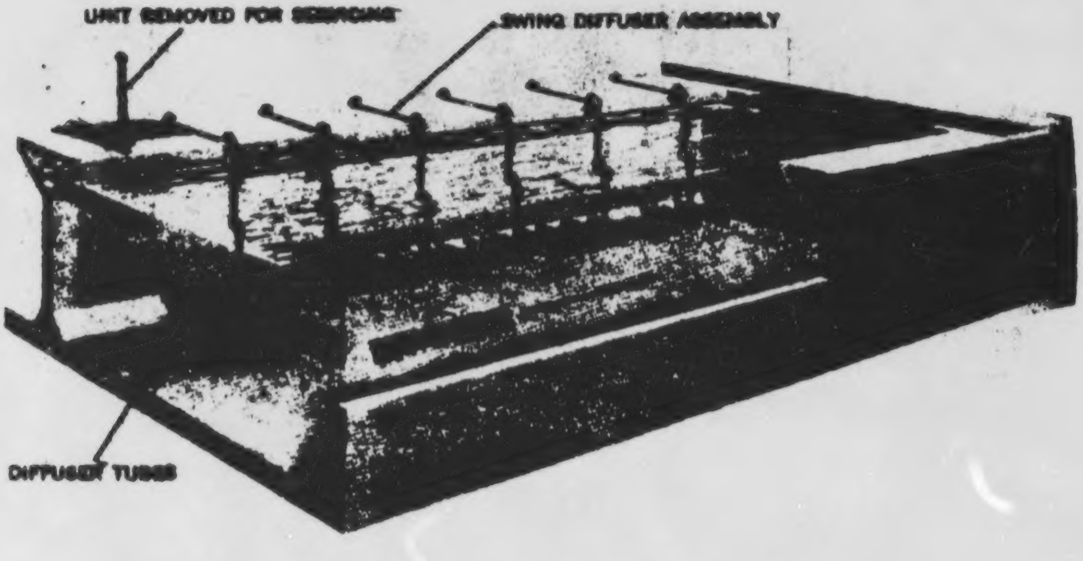

UNIT REMOVED FOR SERVICING
SWING DIFFUSER ASSEMBLY
DIFFUSER TUBES

Figure 13. Cutaway of Aeration Tank Showing Swing Diffuser

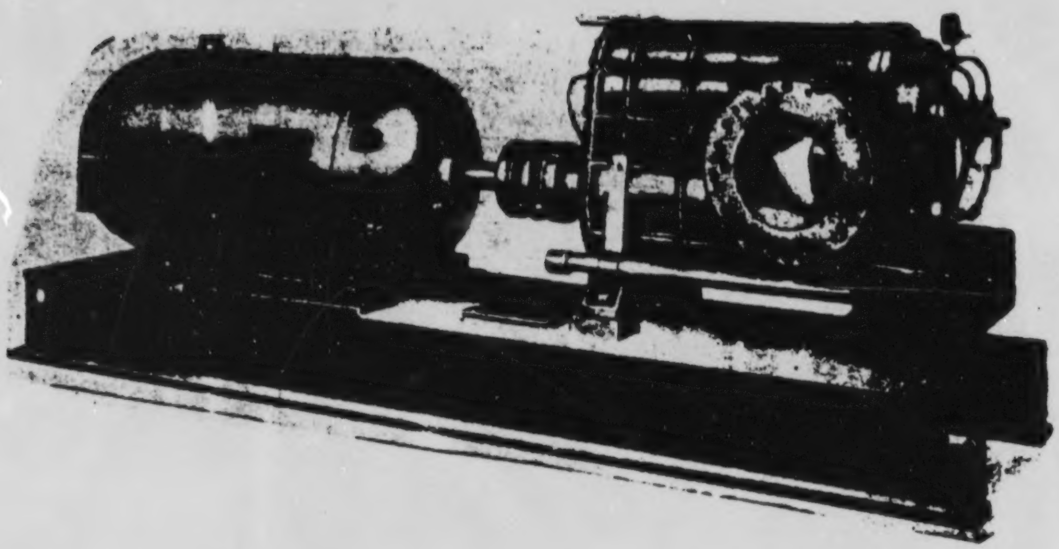


Figure 14. Blower Used for Air Supply to Diffuser System

MECHANICAL. Mechanical aerators use impellers, revolving disks, or brushes for spraying sewage into the air or pulling air down into the sewage.

Figure 15 shows equipment for pulling sewage up through a cone from the bottom of the tank and spraying it into the air. This is done by the motion of the impeller in the upper portion of the cone. Air mixed with the spray is carried downward into the tank.

Figure 16 illustrates another mechanical aerator which forces sewage downward in a draft tube. Air mixed with the sewage at the funnel of the tube is pulled downward and rises from the tank bottom through the sewage.

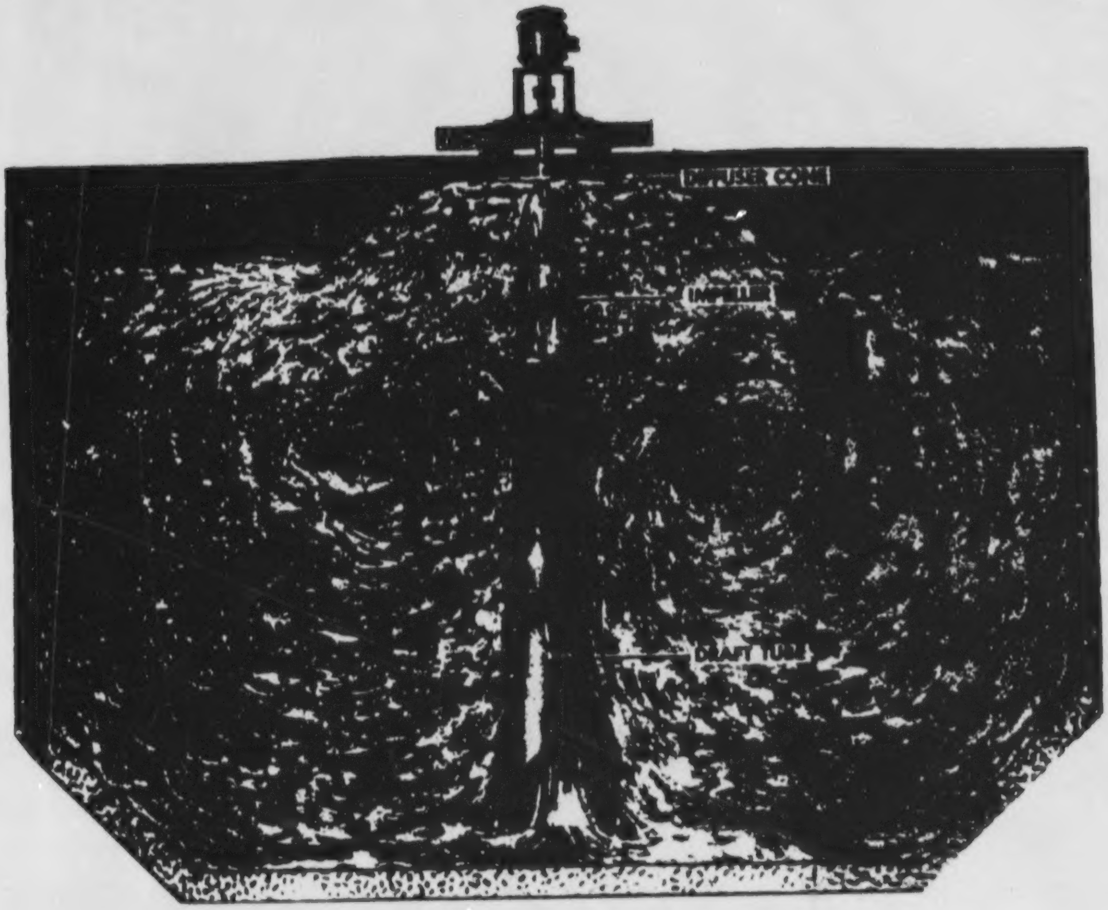

DIFFUSER CONE
IMPELLER
DRAFT TUBE

Figure 15. Updraft Mechanical Aerator

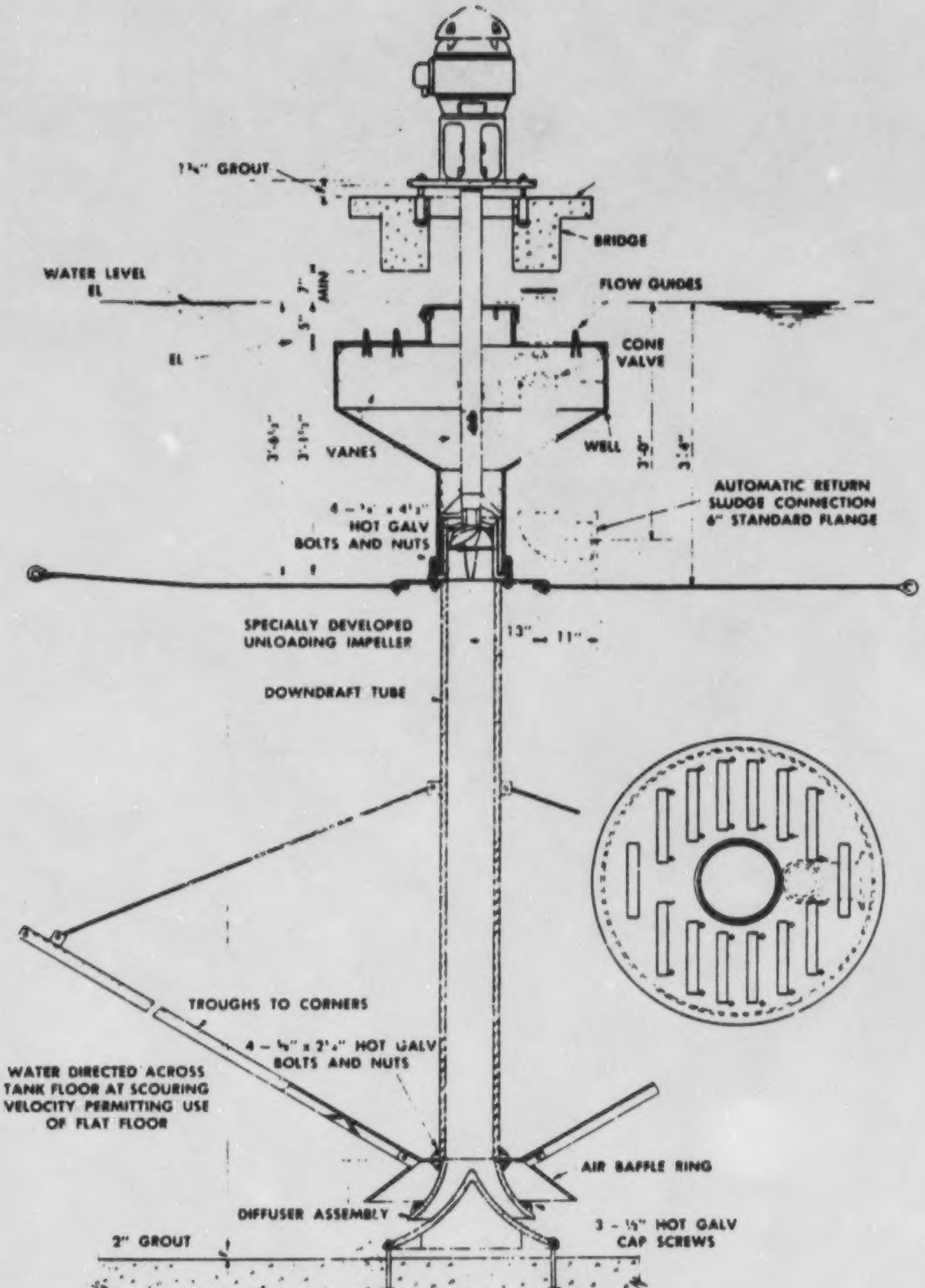

1½" GROUT
BRIDGE
WATER LEVEL
EL
7" MIN
5"
EL
FLOW GUIDES
CONE
VALVE
3'-4½"
3'-1½"
VANES
WELL
3'-0"
3'-4"
AUTOMATIC RETURN
SLUDGE CONNECTION
6" STANDARD FLANGE
4 – ⅝" x 4½"
HOT GALV
BOLTS AND NUTS
SPECIALLY DEVELOPED
UNLOADING IMPELLER
13"
11"
DOWNDRAFT TUBE
TROUGHS TO CORNERS
4 – ½" x 2¼" HOT GALV
BOLTS AND NUTS
WATER DIRECTED ACROSS
TANK FLOOR AT SCOURING
VELOCITY PERMITTING USE
OF FLAT FLOOR
AIR BAFFLE RING
DIFFUSER ASSEMBLY
3 – ½" HOT GALV
CAP SCREWS
2" GROUT

Figure 16. Downdraft Mechanical Aerator

Aeration Tanks and Equipment

The aeration period is the average detention time in aeration tanks, based on the average flow of sewage being treated by the plant plus the flow of return sludge. Aeration tanks utilizing diffused air, which are usually rectangular and narrow, are designed for a detention period of eight hours. Mechanical aerators, generally installed in square tanks arranted in series, are designed for a twelve hour aeration period Sludge is returned from secondary settling units by gravity or pumping. Figure 16 shows the automatic return line for a mechanical aerator. Sludge return is controlled by weir boxes orifices; on gravity lines adjustable sleeves on pipes to the sludge hopper of the settling tank control the amount of return sludge.

Plant Operation

Extent of purification depends upon proper control and adjustment of the biological process. Plant operators must determine the best operating range of all factors involved by systematic trial and establish pro cedures by study and observation to meet variable conditions. These factors include the following:

- Concentration of solids in mixed liquor.
- Settling rate of mixed-liquor solids.
- Volume of sludge return.
- Concentration of solids in return sludge.
- Quantity of air required for various loadings.

QUALITY OF ACTIVATED SLUDGE. High quality activated sludge settles rapidly, leaving a clear, odorless, stable liquid above; it is usually golden brown and has a slight musty odor. The floc usually appears to be granular with sharply defined edges. Settling characteristic may be determined by allowing one liter of mixed liquor to settle for one hour in a graduate and periodically noting the volume of settled sludge. Settling to a volume of 20 to 30 percent in ten minutes indicates good sludge. Figure 17 shows good and poor settling qualities for activated sludge.

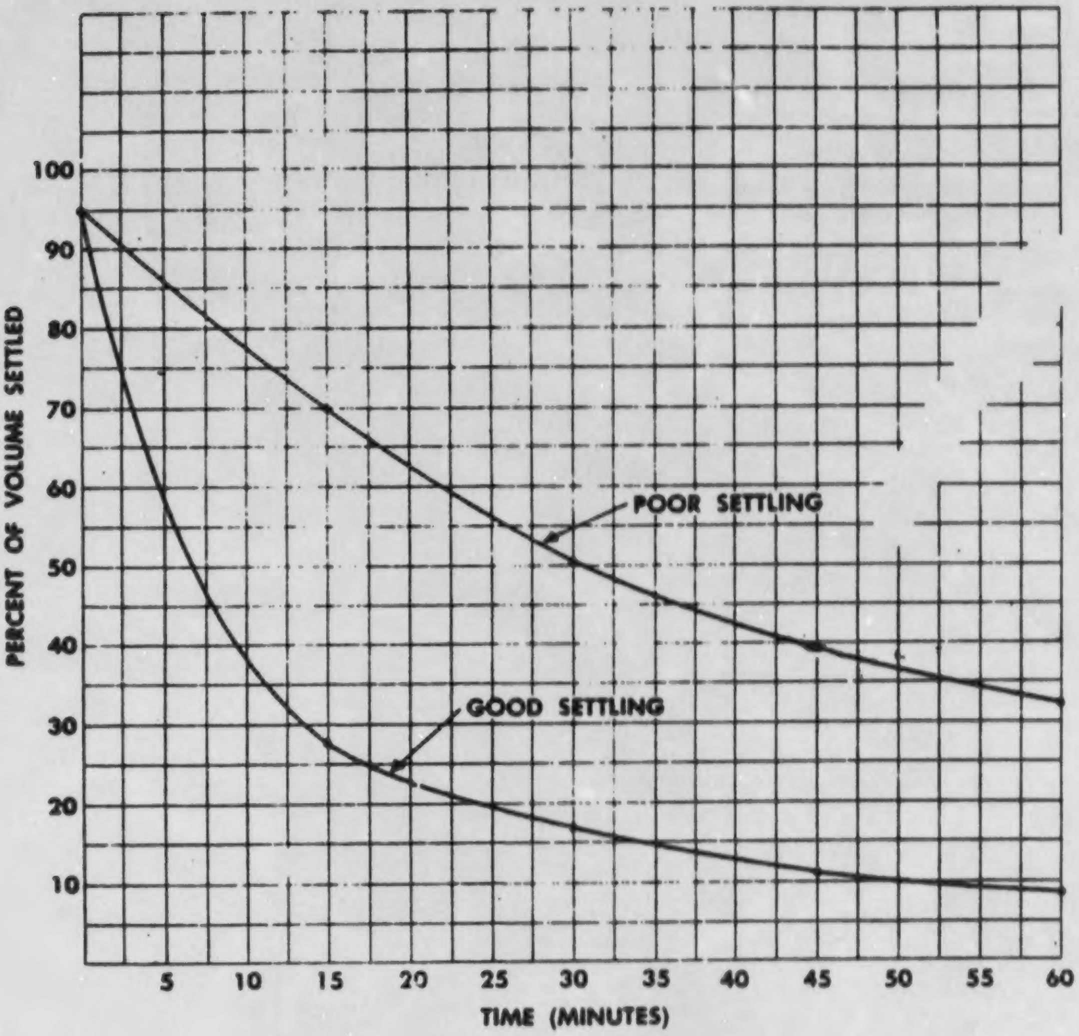


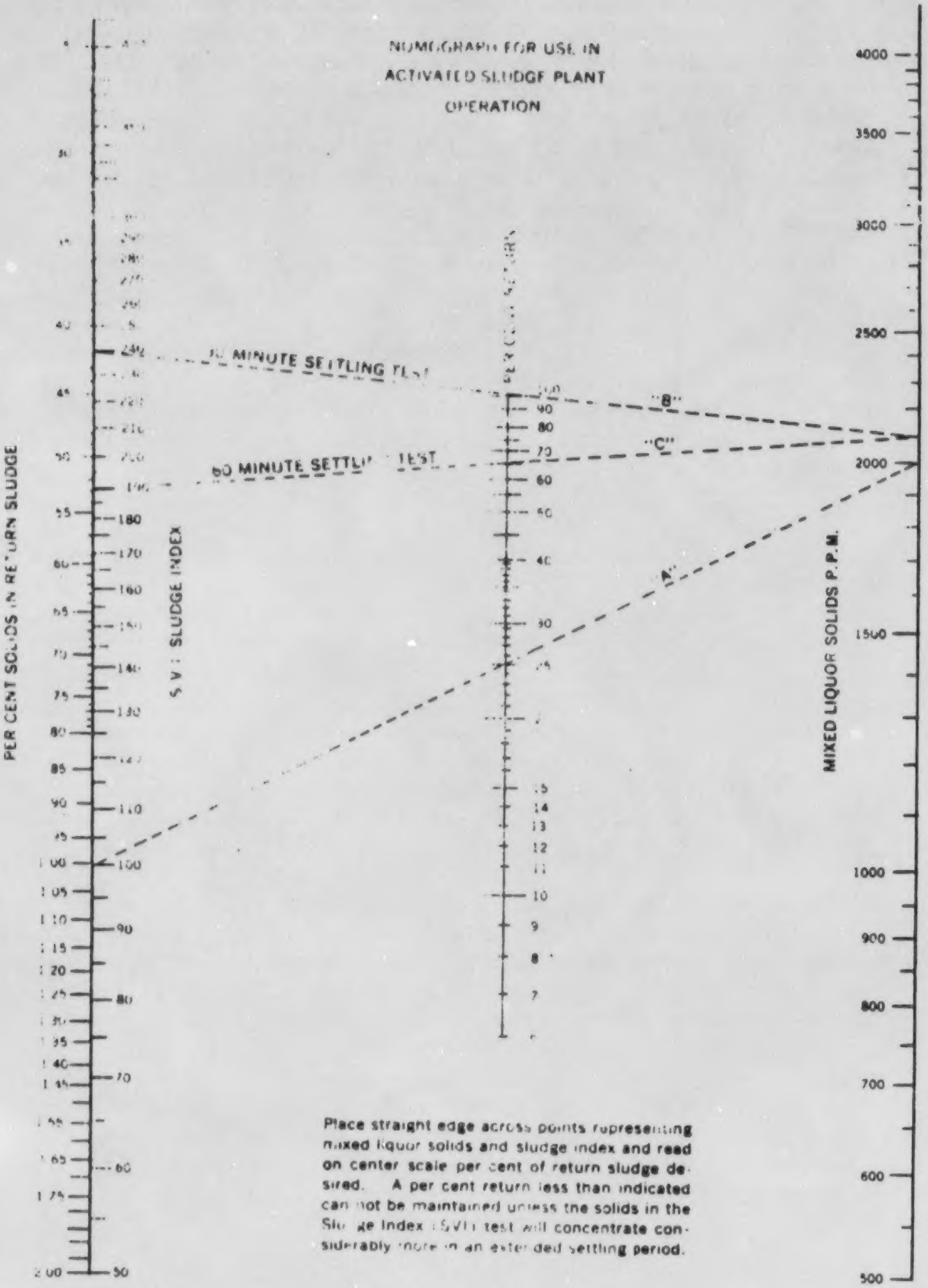
Figure 17. Curves Showing Conditions of Activated Sludge

Density. Dense sludge is desirable. Density expressed as sludge index is computed by dividing percent of volume after 30 minutes settling by percent mixed-liquor suspended solids. Example: If sludge settles to 20 percent volume in 30 minutes with aeration solids at 1,000 p.p.m. (0.1 percent), the sludge index is $\frac{20\%}{0.1\%}$ or 200. An index less than 100 is usually expected in diffused air plants; with mechanical aeration, it usually is 200 to 300. A higher than normal index indicates bulking of sludge. The nomograph presented in figure 18 correlates the sludge index with plant operation data. Assuming (line A) a solids concentration in the mixed liquor of 2,000 p.p.m. (by weight) and a sludge index of 100, it would be necessary to return 25 percent by volume of return sludge with a concentration of one percent (by weight). A higher return could be maintained at increased pumping cost but a lower return would increase detention time of return sludge in secondary settling tanks which is undesirable. Line "B" assuming mixed-liquor solids of 2,000 p.p.m. and a sludge index of 240 (calculated on the regular 30 minute settling period) indicates a return of 100 percent. A lower percentage of return would mean a rapid filling of secondary settling tanks with sludge. There are indications, however, that the concentration of sludge in a test cylinder may be higher at the end of 60 minutes than at 30 minutes, the difference increasing with mixed liquor of poor-settling characteristics. If the calculated sludge index should be appreciably less after one hour test (line C) than after a 30 minute test, a sludge return of 65 percent would provide a correct balance of solids.

QUANTITY OF ACTIVATED SLUDGE. The amount of sludge, measured by the suspended solids in the mixed liquor, must be great enough to produce the desired purification in the available aeration time and low enough to give economical air utilization. Mixed liquor solids concentration, sewage strength, aeration time, and quantity of air are all interrelated.

Proper Concentration. The concentration of mixed liquor solids for best operation under all conditions must be determined for each plant by trial. Aeration solids concentrations of 1, 200 to 3, 000 p.p.m. in diffused-air plants and 500 to 1, 200 p.p.m. in mechanical plants are usual, but they may be varied to suit seasonal or plant load conditions.

Excessive Concentration. Maximum solids concentration to be carried is limited by air supply and raw-sewage load. If solids build up indefinitely, the air and food requirements ultimately exceed the available supply and upsets occur. After the desirable solids concentration in mixed liquor is determined, it is maintained by wasting part of the return sludge. Where shock loads are imposed by sewage varying widely in strength, the solids content of mixed liquor must be enough to absorb the shock. For economy, excessively high solids concentration cannot be carried merely because the available blower capacity permits it. Because of wide variations and high peaks in sewage strength at Army posts, a higher concentration of mixed-liquor solids is necessary than in municipal plants.



Place straight edge across points representing mixed liquor solids and sludge index and read on center scale per cent of return sludge desired. A per cent return less than indicated can not be maintained unless the solids in the Sludge Index (SVI) test will concentrate considerably more in an extended settling period.

Figure 18. Nomograph for Use in Activated Sludge Plant Operation

Tests. Control tests for mixed-liquor and return sludge suspend solids and settled volume are made daily or preferably once each shift.

QUANTITY OF AIR. Although most of the oxygen dissolved in the mixing liquor during aeration is used by the activated sludge, it is only two to five percent of the oxygen supplied to the tanks. Air requirements are governed by B.O.D. loading, quality of sludge, and solids concentration of mixed liquor.

Control. In diffused air plants, air application is usually controlled by blower combinations or variable output blowers. Air supply in mechanical plants is governed by the number of units in service and automatic time switches on each aerator.

Tests. Make dissolved-oxygen determinations daily or preferably each shift, on examples of the mixed liquor collected at the inlet end, middle, and outlet end of the aerators. Inhibitor is used in collecting dissolved oxygen samples to arrest bacterial action and oxygen utilization; otherwise low test results are obtained. These tests indicate whether or not air supply is satisfactory. If one p.p.m. of dissolved oxygen is present at the inlet and progressively builds up to four or five p.p.m. at the end, air supply is adequate.

Excessive Application. Excessive air application is wasteful and may cause the flocculent sludge to be finely dispersed and difficult to settle. Much of it passes over the settling tank outlet weirs.

AERATION PERIOD. Approximately 80 to 85 percent of sewage purification occurs during the first hour of aeration. During the rest of the period, sludge is regenerated, organic matter stabilized, and sludge conditions for further activity. The sludge's capacity for taking in organic matter is limited and regeneration is necessary before an additional load is applied. Activated sludge requires oxygen at a definite, measurable rate. It absorbs oxygen from the water as rapidly with only a few p.p.m. in solution as when the water is almost saturated.

Oxygen Utilization. Oxygen utilization, initially rapid, follows a fairly well-defined, tapering curve to a lower, more even rate as treatment progresses. Time required for purification is in inverse proportion to the amount of sludge. Doubling the quantity of suspended solids in the sewage sludge mixture halves the time for complete oxidation if hydraulic and mechanical conditions permit settling out the increased sludge, and enough dissolved oxygen is available.

Measuring Utilization. Oxygen utilization over a short period of time can be measured by rate of oxygen utilization in p.p.m. per hour. The curve in figure 19 shows what happens to any unit volume of mixed liquor passing through an activated sludge plant. Before treatment starts, return sludge whose liquid portion has a low oxygen demand and raw sewage usually having a low immediate oxygen demand and a high B.O.D. are present. At zero time period of treatment on the curve return sludge and raw sewage are being mixed together and the aeration process started. At this point the rate of oxygen utilization is maximum and remains constant for some time. The length of this period of constant rate of absorption varies directly with strength of sewage and inversely with amount of sludge, other factors remaining constant. After holding for some time, oxygen utilization decreases abruptly at first to an almost constant rate as aeration proceeds for several hours.

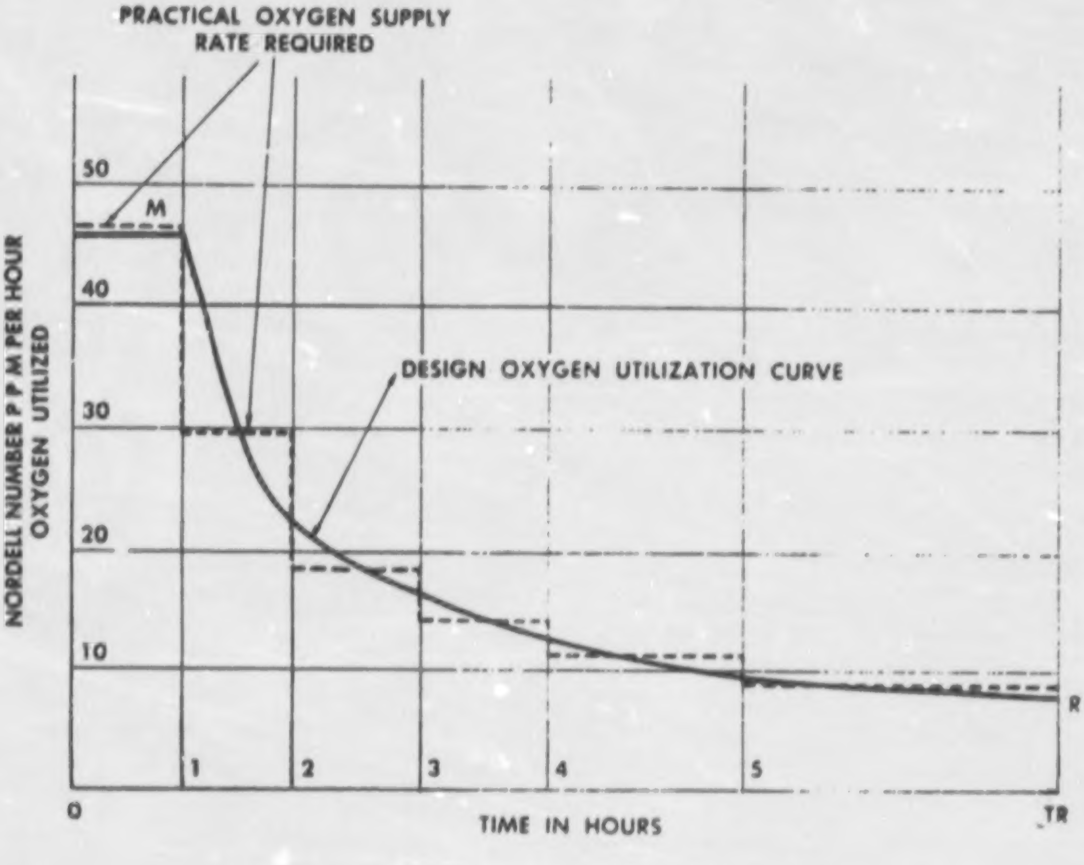


Figure 19. Oxygen Utilization Curve

Use of Oxygen Curve. Characteristic curves show the maximum rate of oxygen utilization to be definitely related to the rate of utilization at completion of the process. This ratio, at least 3:1 and usually 4:1, guides proper adjustment of air distribution to meet oxygen demand. Tapered or step aeration to vary air distribution saves total air used by placing proper amounts where they are needed.

Adjusting Aeration Tanks. Aeration periods of eight hours for diffused aeration and 12 hours for mechanical aeration are desirable. Adjustment to conform to factors discussed above improve plant operation. In mechanical aeration tanks at small installations maintaining dissolved oxygen in first stage of aeration is often difficult. Small diffuser units are installed to booster the oxygen supply.

RATE OF RETURN. Volume of activated sludged returned from final settling tanks to aeration tanks normally ranges from 20 to 40 percent of the raw sewage flow. A high rate of return reduces aerator detention but keeps sludge fresh and may return needed dissolved oxygen to the aerator inlet. A low rate of return increases aerator detention time; it is feasible when the sludge has a low rate of oxygen utilization and does not readily become septic. A high return sludge concentration is obtained with low return rate.

RATE OF WASTE. A division is usually provided to split the flow of returned sludge from the final settling tank either to waste or to aeration tank influent. Suspended solids concentration in the aeration tank and return sludge determine when and how much sludge is diverted to waste. Routine schedules must be developed for wasting sludge in small amounts daily, holding solids in the aeration tank nearly constant. Sludge is wasted slowly and uniformly, generally during the periods of low flow. Rate of waste sludge is normally about ten percent of the return sludge.

FINAL SETTLING TANK. Because settled sludge must be maintained fresh for return to the aeration tanks, the sludge blanket in the settling tank is kept below two feet. Mechanical sludge collection equipment must be operated continuously. Hoppers are squeegeed often to free them of septic sludge. Short circuiting and eddy currents are correct; walls, weirs, and channels are hosed down daily. Rising sludge which is black on the underside incidates that sludge is sticking on the walls or floors; these areas must be kept free of accumulated sludge.

Operating Difficulties

Operating difficulties are usually one or a combination of three conditions; the presence of oil or grease; bulking sludge; and disposal of supernatant from the digester.

OIL AND GREASE. Oils and grease from mess halls or laundry wastes harm bacteria growth in the aeration tanks. The sources of grease and oil are eliminated by proper cleaning of grease traps and oil interceptors. Primary-settling tanks are kept skimmed off.

BULKING SLUDGE. A sudden loss of sludge density shown by poor settling, passage of floc through the final-settling tanks, and increased sludge index is known as bulking. It occurs in two forms: A large diffused floc resulting from loss of biological balance and a light floc containing sphaerotilus, a microscopic threadlike fungus growth. Bulking may be caused by the following: Too high or too low aeration tank solids concentrations, inadequate air supply, inadequate aeration period, and sudden heavy loads on the system such as a heavy dose of strong digester supernatant or an overload of stale or septic sewage solids flushed to the plant by rains after a long dry period, sewage abnormally high in organic solids, especially sugars and starch, or fungus accumulations from the sanitary sewer system may likewise cause bulking sludge.

When bulking results in septic aeration units, wasting the sludge and redeveloping a healthy floc may be necessary. In the early stage of bulking, reconditioning is aided by increasing sludge return and amount of air. Fungus growths usually can be controlled by the following: Applying chlorine to the return sludge in doses of 1.0 to 8.0 p.p.m. of sludge return flow, adding ferric chloride to the mixed liquor and adding copper ammonium sulphate to return sludge.

Rising sludge in final-settling tanks is usually cuased by an excessive retention period forming gases which lift the sludge in chunks. Increasing the sludge return rate to lower the sludge blanket corrects the trouble. This condition also may be caused by nitrification brought on by excessive aeration.

EFFECT OF DIGESTER SUPERNATANT. Disgester supernatant disposal in the activated sludge plant is troublesome, especially when the digester is not functioning properly. Supernatant is usually returned to the plant influent where it passes through the entire plant process. Being well seeded with the organisms of anaerobic digestion, it tends to increase the septic action in the settling units. If discharged intermittently during sludge pumping, it throws a heavy load on the secondary process. If the mixed liquor is not in condition to receive this load, the sludge soon becomes gray and septic.

- Supernatant is returned as uniformaly as possible.
- Returning it directly to the aerator often eliminates the difficulties.
- Returning it to the aerator during low loadings sometimes is successful.

If the supernatant is returned intermittently, the solids in the mixed liquor must be in condition to receive it (higher in concentration). The DO must be carefully watched and increased during the period of necessary.

Records

The following data are reported on the monthly operating logs:

- B.O.D., suspended solids, settleable solids, and relative stability of final-tank effluents.
- DO of mixed liquor at inlet and outlet ends of aeration tanks.
- DO of mixed liquor at inlet and outlet ends of aeration tanks.
- DO of final-settling tank effluent.
- Volume of return sludge.
- Volume of waste activated sludge.
- Suspended solids in mixed liquor and return sludge.
- Percent settled solids volume mixed liquor and return sludge (30 minutes).
- Sludge index.
- Volume of air (in 1,000 cubic feet or hours of operation of mechanical aerators.
- Remarks of unusual conditions such as bulking, its cause and control, peak loads, etc.

CONTACT AERATION

Contact aeration is basically an aerobic biological process. It consists of passing settled raw sewage through aeration tanks that contain plates of asbestos cement or other impervious materials. The surfaces of these materials become covered with zoogleal film of aerobic organisms. Air to support this organic life is blown through diffuser tubes or pipes under the contact media. The biological action is somewhat similar to the action in a trickling filter where biological life forms on the stones instead of plates.

Flow System

A flow diagram of two-stage contact aeration plant is shown in figure 20. Single-stage aeration is generally limited to partial treatment only. Each aerator is divided by an overflow dividing wall into two sections operated in series. This is illustrated in figure 21. Each plant is provided with air blowers and accessories for compressing air and blowing it through the diffuser or pipe system. Facilities for sedimentation and sludge digestion are similar to those used in other treatment processes. Low-head pumps and pipelines for recirculating second-stage aerator effluent to first-stage influent are often added to improve plant effluent and eliminate odors.

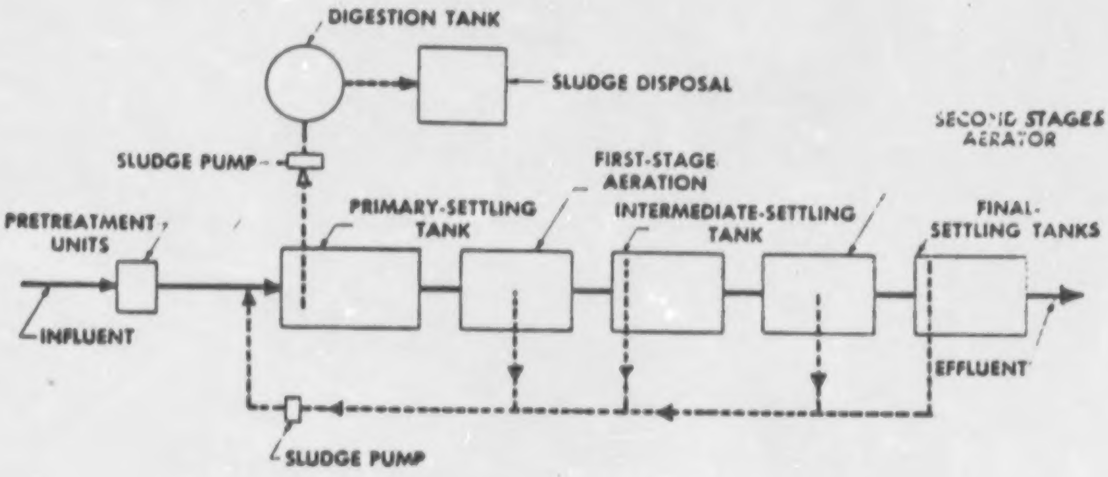

DIGESTION TANK
SLUDGE DISPOSAL
SECOND STAGES AERATOR
SLUDGE PUMP
FIRST-STAGE AERATION
PRETREATMENT UNITS
PRIMARY-SETTLING TANK
INTERMEDIATE-SETTLING TANK
FINAL-SETTLING TANKS
INFLUENT
EFFLUENT
SLUDGE PUMP

Figure 20. Flow Diagram of Contact Aeration Plant

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The biological action in the contact aerator is comparable to that in the trickling filter where organisms form a film on stones instead of plates. Biological life is also suspended in the liquor. Aerators not functioning properly contain organisms causing septic action, such as those commonly found in digesters and other anaerobic processes. Sulfur bacteria are more numerous in contact aerators than in most other secondary treatment units. When dissolved oxygen disappears and an anaerobic condition develops, aerators produce considerable amounts of hydrogen sulfide causing odor problems.

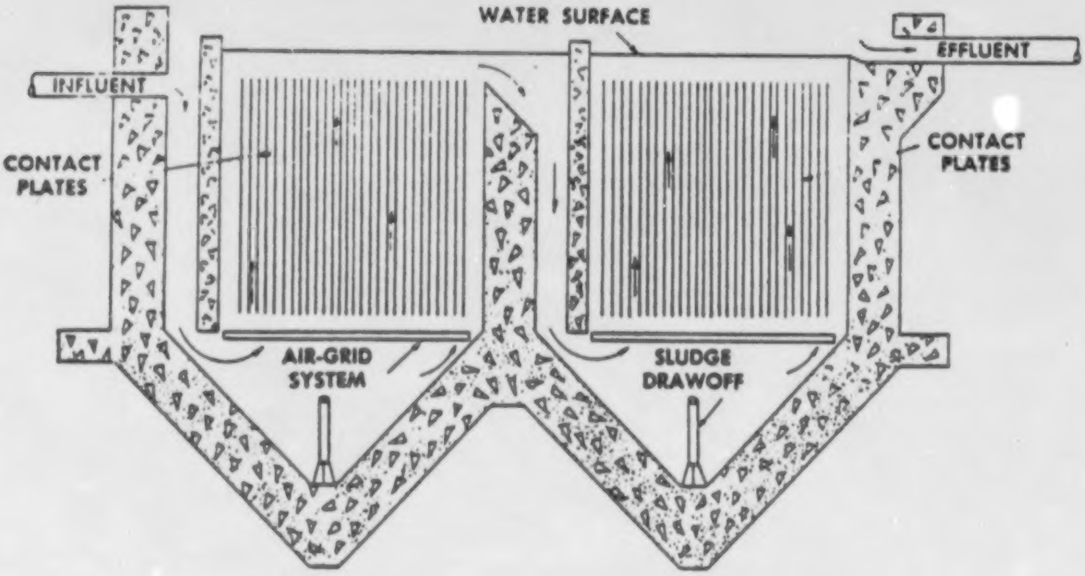

Figure 21. Cross Section of Single-Stage Contact Aerator

Facilities

Facilities for sedimentation and sludge digestion are similar to those used in other treatment processes. Low head pumps and pipelines for recirculating second stage aerator effluent to first stage influent are often added to improve plant effluent and eliminate odors. A typical contact aeration plant is shown in figure 22.

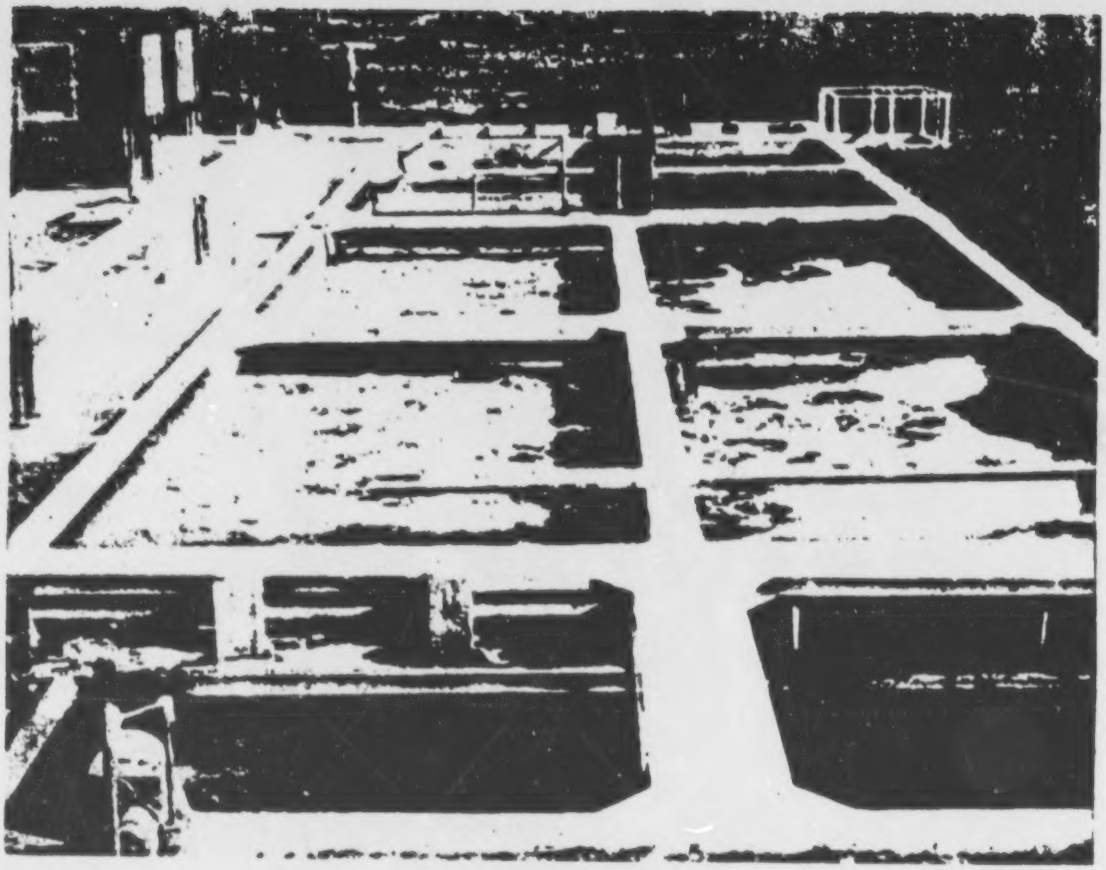

Figure 22. Contact Aeration Plant

For effective operation, an aerobic condition must be maintained in all units following the primary settling tank. Air distribution must be efficient, plate growths must be renewed at intervals, and sludge in units following the primary settling tank must not be allowed to become septic.

Contact aeration requires the screening out of floating and suspended organic matter to protect contact surfaces. Grease and scum must also be removed to prevent them from coating the surfaces and interferring with biological activity in the aerator. Primary settling tanks are usually provided for this purpose.

Recirculation

Recirculation is usually not required in contact aeration except for odor control at full loading. The effluent from the second stage aerator contains the highest concentration of dissolved oxygen and aerobic organisms. When this liquid is returned to the inlet of the first stage aerator, this concentration of dissolved oxygen helps to meet the initial high oxygen demand and the returned organisms seed the mixed liquor and the film growth on the contact plates. This recirculation usually eliminates odors and produces a higher degree of treatment.

Operation of Contact Aerators

The exact operation of all contact aeration plants cannot be given in one hard fast set of rules because each plant is different and varies in operation. The following procedures should be noted when operating a contact aeration plant.

When a contact aerator is placed in operationor returned to service after the plates have been cleaned, apply the primary effluent at a rate not to exceed 25 percent of the normal flow. Sufficient quantities of air diffused into the aerator until a heavy growth appears on the plates. When a dissolved oxygen concentration of 1 p.p.m. is obtained in the first stage, gradually increase the flow and air input until the full flow is obtained, maintaining the D.O. of 1 p.p.m. and 3 p.p.m. respectively. Air valves should be regulated to apply approximately two-thirds of the air to the primary aerator. If adequate D.O. concentrations can be maintained, one or more blowers can be cut off during low flows.

Make sure air is distributed evenly through the contact area of the tank, and air pressure readings should be recorded. Air by-passing any part of the contact surface will result in dead spots favoring anaerobic growths. Clogging of perforations in the air distribution grid is prevented by blowing out the grid daily. At plants with overhead air distribution, drop pipes can be disconnected at the union for removal and cleaning of perforated pipe.

Note and record growth characteristics on contact plates. For this purpose removable observation plates of asbestos cement are placed in each of the aeration sections between the contact plates. The color of the growth indicates its oxidizing power; a brown thin film is most desirable, with a grayish thin film next. A black film or any underlying black portions indicates a septic action, which is undesirable. An odor of hydrogen sulfide (rotten egg) will also tell you that a septic action is taking place in the process. The heavy growths or biologically dead or inactive film must be cleaned off the contact plates. Once these organisms die, they are no longer of any use; they are then removed from the contact plates with high pressure water or compressed air.

Sludge should be drawn from intermediate and final settling tanks at four-hour intervals and returned to the raw sewage flow. To avoid septic conditions, squeegee sludge from the hoppers daily.

Wash down walkways and brush influent and effluent channels every day.

If two or more intermediate settling tanks are used, keep only enough tanks in service to provide 1-1/2 hours detention at the average daily rate of flow.

Dissolved oxygen concentrations in the effluent from each aerator section and in intermediate and final settling tank effluents should be determined each shift. The B.O.D. and suspended solids test on composite samples of raw sewage and of primary, intermediate, and final effluents also should be made.

Record the estimated or metered volume of air used daily; estimate quantity of sludge returned each day to the raw sewage flow; daily quantity and method of recirculation; time at which units are taken out of and returned to service; and the daily average of the results of dissolved oxygen. In general, all records that are kept current can be observed and the plant's efficiency can be determined. They also prove valuable when checking out a new operator on the operation and maintenance of the plant.

SUMMARY

Secondary treatment of waste water is a further decomposition from the primary treatment. There are several units that can be used in the secondary treatment process. You may find some plants using all or a part of them.

The dosing siphon is an automatic device that keeps the trickling filter loaded. The dosing siphon is located in a dosing tank somewhere between the primary clarifier and the trickling filters.

Trickling filters are made up of circular or rectangular tanks filled with rock. Primary effluent is sprayed over the rock and bacterial action further reduces the waste products.

Oxidation ponds are the simplest form of treatment. Under certain conditions they offer economical treatment and disposal. Their use is suited to warm, dry climates.

In the activated sludge process, air is mixed with the sewage in an aeration tank. Since aerobic bacteria are used, then air is necessary for them to live. Regulation of the air supply is very important to the activated sludge system.

Contact aeration is basically an aerobic biological process. It consists of passing settled raw sewage through aeration tanks. Air to support organic life is blown through perforated pipe. Biological action is similar in some respect to that in trickling filters.

QUESTIONS

1. The dosing siphon transfers waste water to what other treatment unit?
2. If a trickling filter began to fill up with water, what would you diagnose as being the trouble?
3. When a trickling filter bed is replaced, how long does it take to reach its full efficiency again?
4. What is meant by ponding in a trickling filter?
5. Why must oxidation ponds be limited in depth?
6. Where sould oxidations ponds be most effective geographicall.
7. Is there an effluent from an oxidation pond?
8. Describe activated sludge.
9. Name the two general aeration methods used for the activated sludge process.

10. Contact aeration uses a biological action similar to what other unit?

11. In contact aeration, on what is the biological film grown?

12. If a hydrogen sulfide odor is coming from the aerator, what would be your diagnosis?

REFERENCE

AFM 85-14, Maintenance and Operation of Sewage and Industrial Waste Plants and Systems

TERTIARY TREATMENT

OBJECTIVE

The purpose of this study guide is to familiarize you with some of the tertiary treatment processes.

INTRODUCTION

Much has been written over a period of many years about the need to control pollution. More recently, there has been a rapid rise in interest in treating waste waters for more direct and deliberate reuse. The advanced waste treatment research program of Public Health Service has begun to develop and demonstrate practical means of treating municipal sewage and other waterborne wastes to remove the maximum amount of pollutants. The purpose of this is to restore and maintain the nation's water at a quality suitable for repeated reuse.

The current terms "tertiary treatment" and "advanced waste treatment" are being used to describe a great variety of sewage treatment processes which range from simple ponds used to polish secondary effluents to complex demineralization schemes. The materials found in secondary effluents which are of concern in most pollution control programs are suspended solids, B. O. D., bacterial concentrations, phosphates, and nitrogen. Where direct water reuse is being considered, removal of soluble non-biodegradable organic materials and dissolved solids may also be necessary.

The processes discussed in this study guide will be limited to some of the main ones; where secondary treatment is inadequate for removal of B. O. D., suspended solids, phosphate, and nitrogen.

Tertiary treatment will be discussed under the following main topics:

* PRINCIPLES OF TERTIARY TREATMENT

* METHODS OF TERTIARY TREATMENT

PRINCIPLES OF TERTIARY TREATMENT

The term tertiary treatment, means third-stage treatment for sewage or wastewater. It is used primarily for polishing secondary plant effluent. The principles used may be physical, chemical, or biological in nature. Some processes used are--plain sedimentation, chemical precipitation, filtration, ion-exchange, activated carbon absorption, electrodialysis, evaporation, liquid-liquid extraction, freezing, reverse osmosis, oxidation ammonia stripping, stabilization ponds, and others. Tertiary treatment can be just about any process used after normal secondary treatment.

The best conventional processes may achieve a 90 percent reduction in B. O. D. and suspended solids and do a good job in reducing microbial contaminants. To go much beyond 90 percent treatment, other methods are needed. No one method of tertiary treatment is the best in every plant, because each plant has different problems and capabilities. In many cases, a combination of some of the processes mentioned are used to meet specific reuse requirements economically.

METHODS OF TERTIARY TREATMENT

Quality requirements for water reuse vary widely. Sometimes B. O. D. plays a part, but more often other characteristics are more important. For example a water that contains gross solids or tends to develop slimes would be undesirable for reuse in most cooling systems. Color, hardness, the concentration of specific minerals and ions, temperature, pH, turbidity, salinity, and uniformity of quality may be determining characteristics for a particular use or treatment method. Sometimes a complete tertiary treatment system may be warranted for the removal of objectional materials.

Filtration

Sand filters, coal filters, and microstrainers have been enhancing the quality of some secondary effluents for years. Following good secondary treatment, plain filtration (filtration without the addition of chemical coagulants) can remove most suspended solids and B. O. D. This makes the effluent suitable for many industrial uses.

D-E Filtration

Studies have been made on diatomaceous earth (D-E) filtration of secondary effluents; where D-E was fed at a controlled rate to the effluent which is then passed through a precoated filter septum. It was found that D-E filtration produced a final effluent with no detectable B. O. D. and only a trace of suspended solids. The major problem associated with D-E filtation is its inability to tolerate significant variations of suspended solids concentrations. A filter run of only ten minutes can occur during periods of high solids, making this process very costly. Even if the secondary effluent turbidity can be maintained at less than 10 units, it has been estimated that the operating cost alone will be 7.5 cents per 1000 gallons, exclusive of the cost of disposing of the spent filter cake. The following discussions will show that other means of effluent filtration can be provided at much lower costs.

Microstrainers

Microstraining is another process that may be used for tertiary treatment. A recent study has shown that a microstrainer with openings of .001 inch would remove an average of 89 percent of the suspended solids found in the secondary effluent. A microstrainer with .0015 inch openings would remove 73 percent. Caution must be observed about the adverse effect of grease and high secondary effluent solids content. The estimated cost of microstraining is about 1.5 cents per 1000 gallons for a plant treating 10 mgd.

One reported problem concerning the ability of a microstrainer to handle wide fluctuations of solid loadings was that an increase in secondary effluent suspended solids from 25 to 200 mg/l caused the output of the strainer to drop from 60 to 13 gpm in a few minutes. As with D-E filtration, microstraining alone does not provide reliable tertiary treatment because it is not capable of handling the variations in suspended solids which occur in most secondary plants.

Slow Sand Filters

Slow sand filters have been used for polishing of secondary effluents. In addition to requiring very large land areas and considerable maintenance, they have been found to be ineffective due to rapid clogging of the filters.

Filter Media Distribution

It is apparent from the above information, that filtration of secondary effluents is a difficult problem. The variations in effluent quality which adversely affect D-E filters, microstrainers, and slow sand filters also have an adverse effect on rapid sand filters.

The sensitivity of a rapid sand filter to high suspended solids concentrations can be readily understood by looking at figure 1. Figure 1 illustrates a cross section of a typical single-media filter, such as a rapid sand filter.

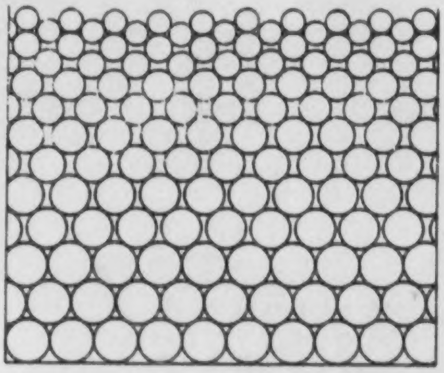

Figure 1. Rapid Sand Filter

Most of the material removed by the filter is removed at or very near the surface of the bed. When the secondary effluent contains relatively high solids concentrations, a sand filter will clog at the surface in only a few minutes. As would be expected from the grain size distribution illustrated in figure 1, 75 to 90 percent of the headloss occurrs in the upper one inch of the rapid sand beds when filtering activated sludge plant effluent.

One approach to increasing the effective filter depth is the use of a dual-media bed with a discrete layer of coarse coal above a layer of fine sand, as shown in figure 2. The work area is extended, although it still does not include the full depth of the bed, as there is some fine to coarse stratification within each of the layers. Effective size of the sand in a typical dual filter is 0.4 - 0.5 mm.

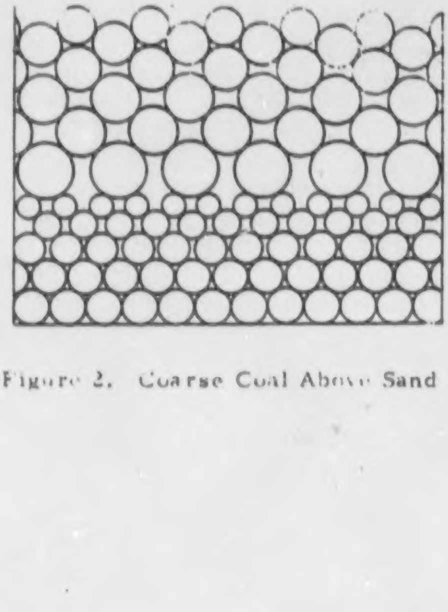

Figure 2. Coarse Coal Above Sand

It has been found that grain size is of major importance in determining how efficiently the filter removes suspended solids. The effluent should pass through as fine a filter material as possible. This presents a serious inconsistency in design of a dual-media bed, as shown in figure 2. It would be desirable to have the coal as coarse as is consistent with solids removal to prevent surface clogging. The sand needs to be as fine as possible to provide maximum solids removal. However, if the sand is too fine in relation to the coal, the sand will actually rise above the top of the coal during the first backwash and remain there when the filter is returned to service. For example, if a 0.2 mm sand were placed below 1.0 mm coal, the materials would actually reverse during backwash, with the sand becoming the upper layer and the coal, the bottom layer. Although the sand has a higher specific gravity, its small diameter, in this case, would result in its rising above the coal at a given backwash rate.

Mixed-Media Bed

To overcome the above problem and to achieve a filter which closely approaches an ideal filter is illustrated in figure 3.

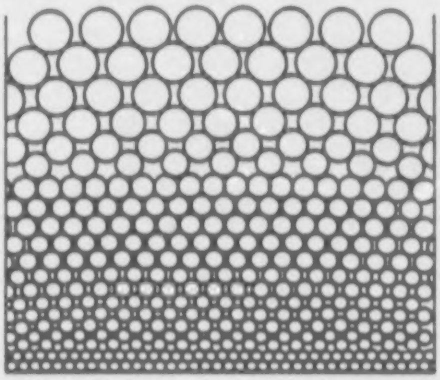

Figure 3. Coarse To Fine

The problem of keeping a very fine media at the bottom of the filter is overcome by using a third, very heavy (garnet, specific gravity of about 4.2) very fine (0.15 mm) material beneath the coal and sand. The resulting mixed-media filter has particle size gradation which decreases from about 1 mm at the top to about 0.25 mm at the bottom. This filter has a coarse upper layer to reduce sensitivity to surface clogging but forces the effluent to pass through a much finer media than does either a sand or coal-sand bed. The uniform decrease in particle size with filter depth allows the entire filter depth to be utilized for floc removal and storage. This discussion describes the effluent quality achieved by mixed-media filtration from a properly designed activated sludge plant. The B.O.D. is less than 5 mg/l; and turbidity, less than 5 units. The cost of this application of mixed-media filtration (including both capital and operating costs) is about 1 cent/1000 gallons.

Although a mixed-media filter can tolerate higher suspended solids loadings than can the other processes discussed, it still has an upper limit of applied suspended solids at which economically long runs can be maintained. With suspended solids loadings up to 120mg/l, filter runs of 15 to 24 hours at gpm/sq. ft. have been maintained. Solids concentrations of 500 mg/l or more will lead to uneconomically short filter runs, even when using a mixed-media filter. A reliable tertiary filtration system will require either a seondary effluent of uniformly good quality, or some intermediate treatment to reduce any extremely high solids concentrations prior to filtration. Since the former is very unlikely, a unique device has been developed which permits supplementary settling of secondary effluent with a minimum of space and cost.

Coagulation and Sedimentation

Coagulation and sedimentation alone can reclaim water suitable for many uses, and they can also prepare secondary effluents for even higher degrees of treatment. The cost is primarily dependent upon the coagulant dose required. Generally, greater quantities of coagulant are necessary to precipitate phosphates than for effective turbidity removal. For example, an alum dose of 25mg/l may produce excellent coagulation and minimum turbidities, but it will reduce the phosphate content only slightly. To remove most of it requires about 150-200 mg/l of alum. Lime doses are usually about twice as great to obtain the same results, but since the price of lime is only half that of alum, costs are comparable.

Efficient coagulation and settling of a good quality secondary effluent will provide a final product with a turbidity of 1 to 2 units. Suspended solids and B.O.D. will be less than 5mg/l. Phosphates can be reduced to 1 or 2 mg/l by using enough coagulant.

Large doses of coagulants yield massive quantities of chemical sludge; however, recovery and reuse are more economical than disposing of the sludge and purchasing new coagulant. Recent studies prove that lime recovery and reuse are feasible.

Filtration and Coagulation

To remove nearly all of the particulate matter requires the filtration of the chemically coagulated effluent. Settling must precede filtration with the use of conventional rapid sand filters. If chemically treated secondary effluent were applied directly to a conventional sand filter, the surface would quickly seal. Only by using mixed-media filters is it possible to eliminate the need for settling of the chemical floc. However, if frequent and severe upsets of the secondary clarifier occur, it is best to provide settling prior to filtration.

At a 2.5 mgd water reclamation plant at Lake Tahoe, the coagulated and filtered effluent (no settling) had a B.O.D. less than 1 mg/l a C.O.D. (chemical oxygen demand) of 20 to 60 mg/l, a phosphate content of 0.1 to 1.0 mg/l, a color of 10 to 30 units, a turbidity of 0.1 to 1.0, and a coliform content of less than 2.1/100 ml following chlorination. No viruses were present. Even with the chemical doses necessary for phosphate removal, the high degree of treatment costs only $80 to $100/mg for a 10-mgd plant. When lower doses are satisfactory, cost may dip to $20 to $30/mg.

Adsorption

Activated carbon is an effective adsorbent. Other materials are also adsorbent in nature but none is as effective as carbon for many classes of organic substances. When municipal activated sludge elements are passed through beds of granular carbon or when powdered carbon is slurried with the effluent, the removal of 70 to 95 percent of the C.O.D.-bearing organic materials are eliminated. The carbon treated effluent is clear and nonfoaming. The organic materials escaping carbon are believed to be largely colloidal.

The principal factors in the use of activated carbon for treating municipal effluents are listed below.

1. Contact times of 15-30 minutes in granular beds or 3-5 minutes with powdered carbon is required.

2. Carbon reactivation is necessary to reduce costs to acceptable levels. Thermal regeneration has been proven practical. The actual technology for reactivating granular carbon on a large scale is known. Reactivation of powdered carbon has been shown feasible, but the technology is in an early stage.

3. Pretreatment of an effluent ahead of the activated carbon may be required.

4. 0.5 to 1 lb of carbon will treat 1,000 gallons of secondary effluent.

5. Preliminary cost projections for reduction of 50 to 70 mg/l of C.O.D. to 10-15 mg/l are from 5-10¢/1,000 gallons of wastewater for plants larger than 10 mgd.

6. Inorganic salts are not removed by carbon.

Electrodialysis

Electrodialysis has the capability of reducing the concentrations of inorganic ions in water and is already a commercially proven process. The brackish water source of Buckeye, Arizona, for example, is converted to a usable supply by electrodialysis.

Studies have shown that inorganic ionic materials in waste effluent can be reduced by electrodialysis on a relatively nonselective basis. The feed to the electrodialysis process should be nearly free from organic contaminants. Suspended solids must also be at a very low level to avoid physical plugging of the electrodialysis cells.

Some of the significant findings on electrodialysis of municipal wastewaters have been as follows:

1. 6-10 kwh/1,000 gallons is the estimated power required to remove 300-500 mg/l of solids.

2. Product to waste volumes of 10:1 can readily be achieved and 50:1 has been accomplished.

3. Total cost for electrodialysis will vary with the amount of materials removed. Preliminary estimates indicate that 15-20¢/1,000 gallons may be the range for municipal effluents. This cost does not include allowance for necessary pretreatment or for ultimate disposal of the brine concentrate.

SUMMARY

The term tertiary treatment, means third-stage treatment for sewage or wastewater. It is used primarily for polishing secondary plant's effluent. The principles used may be physical, chemical, or biological in nature.

Some processes used are plain sedimentation, chemical precipitation, filtration, ion-exchange, activated carbon adsorption, electrodialysis, evaporation, liquid-liquid extraction, freezing, reverse osmosis, oxidation, ammonia stripping, stabilization ponds, and others. Tertiary treatment can be just about any process used after normal secondary treatment. No one method of tertiary treatment is the best in every plant, because each plant has different problems and capacities. In many cases a combination of some of the processes mentioned above are used to meet specific reuse requirements economically.

QUESTIONS

1. Define tertiary treatment.
2. What is the purpose of tertiary treatment?
3. List three main principles of tertiary treatment.
4. List five tertiary treatment processes.
5. What is the reason for the special arrangement of media in the mixed bed filter?
6. List two disadvantages of D-E filter.
7. Name four impurities that can be reduced by tertiary treatment.
8. The organic materials escaping carbon are mostly ______________________________.

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CHLORINATION AND STREAM SURVEY

OBJECTIVE

The objective of this study guide is to develop your understanding of the procedure used in pre-chlorination and post-chlorination of sewage and to familiarize you with stream pollution control and the chemical test used for determination of stream pollution.

INTRODUCTION

The need for sewage disinfection cannot be overstated. The increasing population and the growing demand for water supplies lead us to consider sources that were not suitable years ago. With the population increase comes more need for swimming areas and also more bodies of water to receive sewage plant effluents. Chlorination is used to disinfect final effluents, control odors, and to protect our sources of water.

Chlorine may be obtained in the liquid state, chloride of lime or a sodium hypochlorite solution.

The information regarding pre- and post-chlorination of sewage and pollution control by stream surveys will be presented in this study guide under the following main topics.

- PRE-CHLORINATION
- IN-PLANT CHLORINATION FOR OPERATIONAL CONTROL
- POST-CHLORINATION
- STREAM SURVEYS
- STREAM ASSETS AND LIABILITIES
- LOCATION OF STREAM ANALYSIS
- CORRECTIVE MEASURES
- RECORDS

PRE-CHLORINATION

Pre-chlorination is the adding of chlorine to sewage as it enters the plant. Disinfection of raw sewage without further treatment is not practical because of limited effect of chlorine on large solids as well as being expensive.

Low Flows

Pre-chlorination may be used to keep sewage fresh and prevent odors when sewage flows are below the rate for which the treatment plant was designed and detention periods in settling tanks are excessive. The amount of chlorine required depends on how putrid the sewage is when it reaches the plant. A dosage up to 5 ppm, even without residual, is usually effective.

Odors

Chlorine acts immediately on hydrogen sulfide gas to prevent odor. Influent to trickling filters may also be pre-chlorinated to control odors. This is usually done only when prevailing winds are in the direction of inhabited areas. Elimination of foul odors from sewer systems and treatment plants throughout the year is increasingly difficult. With the rapid growth of population and modern highways into the outlying districts the problem has become worse in recent years.

IN-PLANT CHLORINATION FOR OPERATIONAL CONTROL

In some areas of plant operation, chlorination is used. This type of chlorination is neither pre- or post-chlorination but is defined as in-plant chlorination.

Filter Control By In-Plant Chlorination

Ponding of trickling filters can often be corrected by applying heavy doses of chlorine to the filter influent. A residual up to 5 ppm applied 3 or 4 hours daily for several days causes the solids to crumble and fall away from the filter rocks. Application is best made at night when sewage flow and chlorine dosage are low.

Filter flies can be controlled somewhat by chlorination to a residual of 0.5 to 1.0 ppm for several hours at 2 week intervals. Care must be taken not to decrease filter efficiency by destroying bacterial growth.

Activated Sludge Control

Chlorine may be applied to return activated sludge to correct bulking caused by fungus growths. The dosage depends on the solids content of the sludge; over-chlorination must be avoided because it may effect the biological life in the activated sludge.

Chlorination may be started by applying approximately 1 ppm (based on return sludge flow) and increasing the dosage daily by small amounts until a slight turbidity is noted in the final tank. Dosage should then be decreased. In most cases the maximum dose should not exceed 8 ppm.

If a bulking has been continuous or continues to reappear whenever chlorination is stopped, a small amount of chlorine applied continuously (after bulking has been remedied by heavier chlorine dosage) may help to maintain a low sludge index. In some cases this may also be accomplished by continuous low chlorine dosage of the incoming raw sewage.

POST-CHLORINATION

Post-chlorination is chlorination of sewage plant final effluents to reduce bacteria and B. O. D.; it is usually used only when necessary to protect the receiving stream. Determination of the necessity to use post-chlorination is made by the major air command.

Disinfection Of Plant Effluents

Disinfection is generally necessary when sewage effluents are discharged to bodies of water used for domestic water supply, reproduction of shellfish, recreation or training activities, and irrigation. Disinfection may be regular as when supplies are endangered, or seasonal as when the stream is used for swimming. During rainy seasons or periods of high run off, disinfection may not be necessary because of the increased dilution of sewage by heavy flows. Because chlorine demand and sewage flow will vary the chlorine residual of the effluent should be checked hourly so the rate of chlorine feed may be adjusted.

Complete sterilization of sewage is not practicable or economically feasible, but the reduction of bacteria count in settled or treated sewage effluents is as high as 99.5 percent following chlorination for a 15 minute contact period with a residual of 0.3 to 0.5 ppm. This residual will usually kill all types of disease-producing bacteria and insure effective disinfection.

A 15 minute contact detention period is necessary to provide time for chlorine to contact and kill organisms. This may be in a separate contact chamber baffled to prevent short circuiting (see fig. 1) or in the outfall sewer if it is long enough.

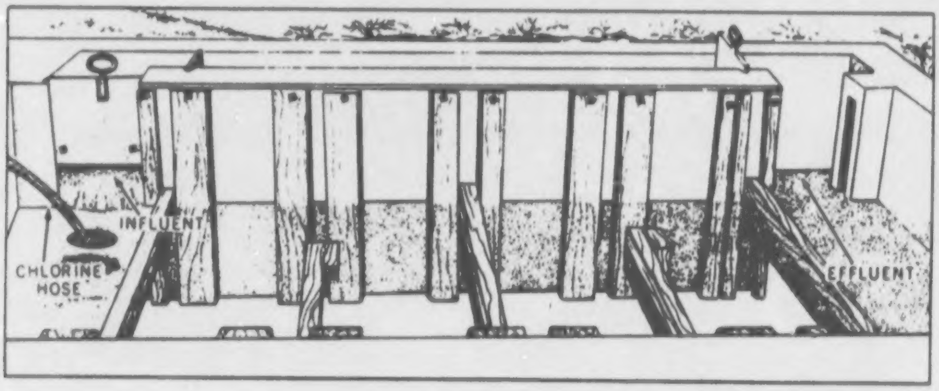

Figure 1. Chlorine Contact Tank

Reduction of B. O. D.

Each ppm of chlorine added to sewage effluent reduces B. O. D. in the receiving stream by 1 to 2 ppm. This B. O. D. reduction is effective in preventing septic conditions or low dissolved oxygen content in a stream where the dilution factor is low. The effect is lost however if there are sludge banks in the stream below the outfall.

For post-chlorination to protect receiving streams, a chlorine residual up to 0.5 ppm is adequate although higher residuals may be required during low stream flows. Post-chlorination is not a cure-all for poor stream conditions and cannot replace proper sewage treatment and correct operations.

STREAM SURVEYS

Stream surveys should be made once each week on successive days (Monday the first week, Tuesday the second week and so on). Collect the samples shortly afternoon on these days.

Purpose of Stream Survey

A stream or large body of water is commonly used for final disposal of liquid wastes. Sewage is usually treated to some extent before such disposal. The extent of treatment required depends on the ability of the stream or body of water to absorb wastes without pollution.

The requirements of the receiving water is the first consideration in establishing the basis for design of the treatment plant and thereafter operators must know and meet these requirements consistently.

Other items in a stream survey are noting stream conditions, such as turbidity, presence of algae or types of fungus, sludge deposits, vegetation on stream bottom, fish life, oil, and odor; estimating relative stream flow, such as high, average, or low; or gaging flow when a gaging station is near. When effluents are discharged to lakes or tidal waters, stream tests should be modified according to technical recommendations of major command sanitary engineers.

STREAM ASSETS AND LIABILITIES

Unless it is grossly polluted, every stream or body of water has certain assets to balance against the liabilities of pollution. All natural waters are somewhat polluted by vegetation if not by sewage or wastes. B.O.D. is a liability. On the other hand, the concentration of dissolved oxygen in water and its ability to absorb oxygen from the surrounding air (reaeration) are assets. Removal of oxygen from the water to satisfy B.O.D. is called deoxygenation.

Oxygen is less soluble in warm water than in cold water, so there is less oxygen available to combat organisms during summer flows when decomposition is most rapid. For this reason, and because of accompanying lower stream flows summer is the critical season of the year for stream protection.

Sunlight promotes the growth of algae, which produces oxygen during the day and helps to stabilize organic matter in the stream. Heavy pollution may deplete the oxygen during the night when algae is inactive. Because of this, sunlight conditions may affect results of stream surveys. Algae and other vegetation use the nitrogen, carbon dioxide mineral, and other compounds in air and water for growth and development. Treatment of sewage effluents to a point of high nitrification is not always desirable because it promotes abundant vegetation that

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eventually decomposes and causes serious natural pollution which, in some cases, may exceed pollution caused by sewage.

Solids from natural sources carried by the stream and those produced by sewage effluents tend to settle in the stream bed, forming sludge banks where anaerobic decomposition takes place. Figure 2 shows a section of such a deposit. There is actually a gradual grading between the aerobic and anaerobic zones rather than the definite line shown.

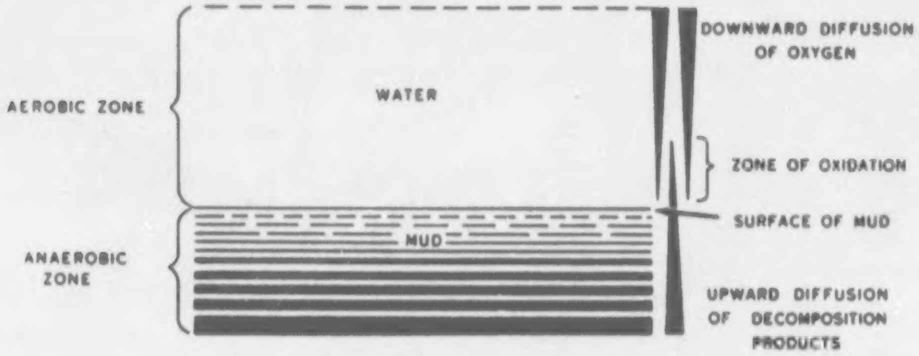
DOWNWARD DIFFUSION OF OXYGEN
AEROBIC ZONE
WATER
ZONE OF OXIDATION
SURFACE OF MUD
MUD
ANAEROBIC ZONE
UPWARD DIFFUSION OF DECOMPOSITION PRODUCTS

Figure 2. Section of Sludge Deposit in Stream Showing Zones of Action

LOCATION OF STREAM ANALYSIS

Select at least three sampling points as follows: above the sewer outfall, point of discharge below a point where sewage and water are well mixed; or several miles below the outfall at the critical point for definite flow and weather conditions, which is the point of minimum dissolved oxygen as determined by trial and past records.

Samples should be collected at each established sampling point for the determination of B. O. D. and dissolved oxygen. Note, the water temperature at each sampling point. Where sewage effluents are discharged above water supply intakes, stream samples for bacteriological analysis may also be required.

CORRECTIVE MEASURES

The following sewage treatment procedures are essential for correction of stream pollution; removal of solids to prevent sludge deposits, reduction of B. O. D. in solids and in solution; reaeration of plant effluent by methods such as the step aerator shown in figure 3; treatment to the point of low nitrification if algae are detrimental to stream purification; under critical conditions, chlorination of plant effluent, which tends to delay deoxygenation.

RECORDS

Records of stream surveys are valuable aids in controlling treatment operations, as well as in the design of alternations and additions to the plant. In the event of damage claims based on alleged stream pollution or nuisance, such records are important legal documents. The result of all test and observations should be recorded on the Sewage Utility Operating Log (supplemental).

Summaries of stream surveys shall include general conditions of weather and stream flow, distance of sampling points from the outfall, dissolved oxygen, B. O. D., and percent of saturation.

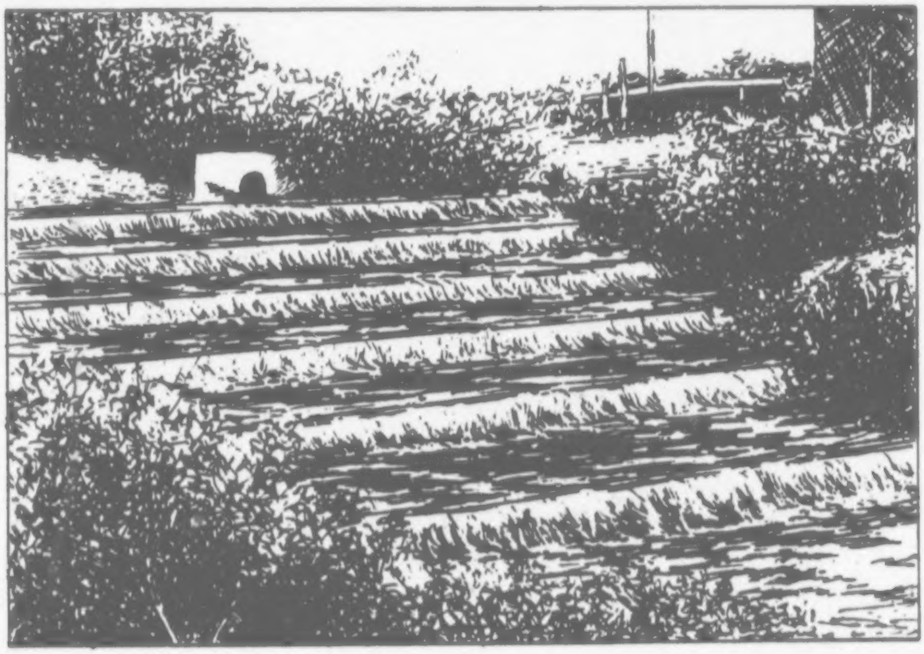

Figure 3. Step Aerator for Increasing Oxygen in Stream

SUMMARY

Chlorine is used in sewage disinfection and odor control. It comes in several forms but is commonly used in the gaseous state. Pre-chlorination is the application of chlorine to sewage as it enters the plant inlet while post-chlorination is accomplished by chlorinating the final effluents to reduce bacteria and B. O. D. Stream surveys are necessary for stream pollution control. Stream surveys include visual observation of the receiving stream and applicable chemical analysis. Stream survey records will indicate the need for corrective measures or adjustment if necessary. Such records are good legal documents and aid in change or design alterations of a plant.

QUESTIONS

1. Why is chlorine added to sewage?
2. Define pre-chlorination.

3. Define post-chlorination.

4. How long a contact detention period is required to provide time for chlorine to contact and kill organisms?

5. Why are stream surveys performed?

6. How often are stream surveys made?

7. List the three sampling points of a stream survey.

8. List five visual items to be observed during a stream survey.

9. Why is summer the critical season for stream protection against pollution?

10. What is a step aerator?

11. Give three reasons why stream survey records are valuable.

12. What is deoxygenation?

REFERENCES

AFM 85-14, Maintenance and Operation of Sewage and Industrial Waste Plants and Systems.

INDUSTRIAL AND RADIOACTIVE WASTE

OBJECTIVE

The purpose of this study guide is to familiarize you with the proper procedure in treating and disposing of industrial and radioactive wastes.

INTRODUCTION

Industrial wastes differ from domestic or sanitary wastes (sewage) since it contains many contaminating chemicals. Industrial and radioactive waste are more difficult to treat than sanitary wastes since they provide a potential to water pollution. It is the responsibility of the installation engineer to supervise in the treatment and disposition of industrial wastes. This is accomplished in such a manner as to meet antipollution requirements which are established by State control agencies.

Air Force personnel may encounter radiation which is produced by many sources on an installation. The equipment which produces these radioactive wastes are reactors, radioactive isotopes, X-ray machines, and electronic equipment. The radioactive equipment or materials produce X-rays, gamma rays, and beta or alpha particles which over a period of exposed time may cause severe injury to personnel.

Information on industrial and radioactive wastes will be covered under the following main topics:

- TYPES OF INDUSTRIAL AND RADIOACTIVE WASTES
- HAZARDS OF UNTREATED WASTES
- INDUSTRIAL AND RADIOACTIVE WASTE SURVEYS
- GENERAL TREATMENT METHODS
- PROCEDURES FOR HANDLING AND DISPOSING OF RADIOACTIVE WASTES
- GOOD MAINTENANCE PRACTICE

TYPES OF INDUSTRIAL AND RADIOACTIVE WASTES

Industrial and radioactive wastes generated at Air Force installations are chiefly products of equipment repair, aircraft and vehicle washing, cleaning of equipment, and the use of chemicals. These wastes are as varied as commercial operations themselves; and, therefore, treatment for each type of waste must be considered separately. Each type of treatment must be modified to satisfy the requirements of the different state water pollution laws. Some of the wastes you will be concerned with are cyanides, chromium compounds, acids, alkalies, organic solvents, and products of radioactive materials.

Cyanides

Cyanides are produced in metal plating, steel hardening, rust prevention and stain removal processes. Cyanide wastes require separate treatment from other types of wastes since it produces a source of danger to potable water. In most cases waste cyanides have concentrations of less than 0.5 ppm because of its dilution with water.

Chromium Compounds

Chromium compounds originate from chromic plating, blight dipping, copper stripping, and anodizing operations. Other toxic wastes, such as copper, lead, and zinc, ar produced in metal plating operations. When these wastes are above a certain concentration they become toxic to the anaerobic sludge digestion processes at the sewage treatment plant. Compounds of chromium are not all equally toxic. Chromic acid and chromic salts, especially potassium and sodium bicarbonate, are far more toxic than th natural salts and oxides.

The US Public Health Service drinking water standards list the following maximum allowable concentrations:

Hexavalent chromium	0.05 ppm
Lead	0.1 ppm
Copper	3.0 ppm
Zinc	15.0 ppm

Acids and Alkalies

Acids and alkalies are produced in the pickling and cleaning operations of metals. Acid wastes interfere with sludge digestion and biological action in the treatment processes. Excessive acidity will also cause corrosion damage. The average critical concentration of sodium hydroxide and calcium hydroxide is 100 ppm.

Where both acid and alkali wastes are involved, the mixing of the two may provide the required pH correction.

Organic Solvents

Organic solvents, phenols and aniline, are waste products in paint removal, cleaning of equipment and research. The average pH values of organic cleaning compounds range from 7.0 to 9.0, and the solvents contained interfere with bacterial activity in sludge digestion. These solvents and phenol cause objectionable tastes and odors in water supplies.

Greases, Oil Emulsions, and Detergents

These wastes result from cleaning of aircraft, ground power equipment, motor pool, and laundry operations. Grease and oil wastes must be segregated to avoid coating carrier systems and treatment units and increasing B.O.D. Grease-oil coatings will also interfere with the efficiencies of precipitants used for sedimentation of industrial wastes.

The acceptable limit of oil concentration in wastes ranges from 15 to 30 ppm, depending on stream usage. Laundry wastes, which usually carry pH values from 9.0 to 10.8, release carbon dioxide which causes partial sludge flotation.

Radioactive Wastes

Radioactive wastes may be encountered by AF personnel since this radiation is produced by many sources. It becomes important for you to know the nature of a particular operation and guard against accidental exposure to radioactive materials. Another means of determining if radioactive substances are involved is to check the operation with a radioactive survey meter. There are several types of radiation which will cause serious injury if you are exposed. The types of radiation most often encountered are X-rays, gamma rays, and beta or alpha particles.

HAZARDS OF UNTREATED WASTES

Many hazards are developed from untreated wastes such as, fire and explosions, toxicity, and interference with stream purification. In addition, there are odor, sight, and taste nuisances.

Fire and Explosion

Highly flammable compounds and vapors in industrial wastes create fire and explosion hazards, particularly when discharged freely into sewers or to the ground. Vapors from volatile solvents, fuels, and oils may travel considerable distances in certain soils and form explosive concentrations in low, enclosed places such as basements. Wastes with a high solid content may cause deposits that form explosive gas as they decompose.

Toxicity

Certain industrial waste waters are poisonous to human beings, livestock, and aquatic life, either by direct contact or by contamination of water supplies. Metal finishing wastes, such as cyanide and chromium, and certain organic compounds are highly toxic in minute concentrations if discharged to receiving streams or to ground water strata. Discharge of these wastes must be stringently controlled. Hydrocyanic gas, which may be produced in the acid treatment of cyanide wastes, is also extremely poisonous. The formation of sludge deposits by certain industrial wastes can create a potential health hazard to prospective users of the stream, as well as restrict or make impossible its use for recreational or agricultural purposes.

Interference with Stream Purification

The self-purification of streams depends largely on sufficient oxygen supply to support the life and activity of fish and other aquatic organisms. Oil and grease form mats and slicks that hinder reoxygentation of streams. Wastes with heavy organic loads utilize available oxygen and form sludge deposits that interfere with stream self-purification processes. Acids and caustic materials in strong concentrations destroy fish and other living organisms; cyanide and chromium wastes are particularly toxic to fish and supporting flora and fauna.

Odor, Sight, and Taste Nuisances

Grease, oil, and chemical wastes may cause unsightly and odorous mats on stream surfaces and open channels, and create objectionable tastes in potable water.

INDUSTRIAL AND RADIOACTIVE WASTE SURVEYS

The importance of surveys has been noted in connection with the treatment and disposal of sanitary sewage. Surveys are necessary to determine the source, character, and volume of industrial wastes. This provides guidance in the design of treatment plants and helps to avoid water pollution.

Flow Measurements

The flow of wastes should be measured at representative points and expressed in standard units of measurement. The standard units of measurement are gallons per minute (gpm), gallons per hour (gph), or gallons per day (gpd). The method used to determine the volume of wastes depends on the size of flow. Common metering devices include weirs, nozzles or flumes, and flowmeters.

Sampling

Accurate sampling is necessary for correct analysis of industrial wastes. The samples should be taken in direct proportion to the flow and properly preserved before analysis. A recommended sampling interval is 10 or 15 minutes; the maximum period should not exceed 1 hour.

Representative Samples

Samples must be representative of the entire body of wastes. Unsatisfactory sampling techniques can make laboratory tests useless or misleading. A careful procedure is necessary to obtain representative samples because the waste can vary in concentration throughout the day.

Grab Samples

Grab samples, or single samples taken at one point, do not give a reliable indication of the average waste throughout the day. Grab samples are taken for the following tests; DO, pH, chlorine demand, residual chlorine, settleable solids, and relative stability.

Composite Samples

These samples consist of individual samples taken at regular intervals, hourly or halfhourly, over a selected period of time. These samples are combined as they are collected or at the end of the sampling period combined into a single container. Composite samples are taken for the following determinations: suspended solids, B. O. D., total and volatile solids of sludge, grease and nitrogen.

Analysis of Samples

In addition to anlysis for any toxic materials peculiar to the particular waste, State water pollution control authorities establish limits for: B. O. D. (biochemical oxygen demand), pH, DO (dissolved oxygen), total solids (suspended and dissolved), temperature of the waste, color, turbidity, oil, and grease.

Effects of Operating Schedules

An important factor in industrial waste surveys is the determination of "when" and "how" wastes are discharged. Flow measurements and sampling are affected by the following consideration:

- The type and quantity of specific wastes produced may vary during the operating day.
- Wastes may be discharged in batches at set times during operation or at cleanup time.
- The method of discharge may involve combining wastes, or handling different specific wastes separately and at different times.

Records

Daily samples of effluent taken for analysis must be properly identified and test results recorded for guidance in future operations. Effluent must be measured, and accurate records kept of total daily flow. Industrial waste surveys should be run for a duration of at least one week; the minimum accepted survey time is three 24-hour periods. Record this information on the Sewage Utility Operating Logs.

GENERAL TREATMENT METHODS

Reducing Waste Concentration

Many agencies generating industrial wastes can reduce the amount and concentration of those wastes by proper handling of waste materials and by observing accepted practices of good housekeeping. Waste materials can be properly segregated according to groups in holding tanks and treated in concentrated form when the quantities involved are large enough to cause operational difficulties if included in the general waste flow. These materials would include concentrated acids, concentrated alkaline solution, hydrocarbons, cleaners, solvents, plating solutions, cyanide wastes, phenol compounds, and solutions of a similar nature. A pickup service can be established to collect the wastes and transport them to the industrial waste plant where disposition can be made at times and rates most favorable to plant operation.

Combining Wastes

The most desirable and economical method of treating industrial wastes is to combine them with sanitary sewage for treatment in the same plant. Some pretreatment, however, is generally necessary to prevent the damaging effect of acids, alkalies, oils, and greases on treatment units and interference with biological treatment methods.

Consideration should always be given to grouping industrial wastes because of the operating economies involved. Acid wastes, for example, can be grouped with highly alkaline wastes; the acids can thus be neutralized without the expense of adding a special neutralizer such as lime. A small volume of waste with a high B. O. D. can be diluted by a another large volume of waste that is low in B. O. D. By such combinations, industrial wastes may be brought into the range of biological treatment as used in treating sanitary sewage, thus permitting treatment with sanitary sewage.

Type of Treatment

Three general types of treatment can be applied to industrial wastes: physical, biological, and chemical. Combinations of these types may be required in specific situations.

PHYSICAL. Physical methods of treating wastes sometimes use the equipment and processes of chemical engineering, especially, for recovery of materials; however, they are generally the same as for sanitary sewage. Such treatment is often necessary because of the nature of some industrial wastes or as a preliminary to other types of treatment.

1. Screening is utilized to remove large solids or stringy materials. Inert materials such as grit and sand are removed by means of grit chambers.

2. Flotation by aeration is used to remove oils, fats, and greases from industrial wastes.

3. Sedimentation or settling by gravity is utilized for substantially complete removal of settleable solids and removal of 35 to 50 percent of suspended solids. Separate settling tanks with mechanical collection equipment are commonly used.

4. Gravity type oil separators should be installed for activities producing large amounts of oily wastes if more refined types of oil separators are not warranted. Preventing oil and hydrocarbons from reaching the industrial waste lines will reduce fire and explosion hazards in these structures. Provisions should be made to assure that oil removed from separator units may be disposed of by any of the following methods:

    a. Resale to refineries (waste oil).
    b. Use for insect control.
    c. Use as a road-binder.
    d. Use as a carrying agent for weed killers.
    e. Use by fire department for drill purposes.
    f. Burning in approved burning pits.

BIOLOGICAL. The oxidation of organic matter by bacterial action is the most economical waste treatment available, but some form of pretreatment is generally required for industrial wastes.

Trickling filters provide effective treatment for wastes that are high in B. O. D. and low in suspended solids.

The activated sludge method is useful where the organic loading is relatively uniform. In general, this process is sensitive to shock loads and toxic materials and requires careful operating control.

CHEMICAL. The addition of chemicals is designed to coagulate suspended or colloidal solids, to break grease and oil emulsions, and to neutralize strong acid and alkaline wastes. This type of treatment frequently involves expensive chemicals, so efficiency must be balanced against economy. If chemical and biological treatments are to be combined, consideration must be given to the fact that strong acids and alkalies inhibit or interfere with bacterial action. Specific chemicals are required for various wastes such as lime, sulphur or chlorine compounds, for cyanides and several sulphur compounds for toxic metal wastes. Chemicals can be fed dry or in solution.

Strong acid or alkaline wastes often require neutralization by chemical means before final disposal. Where both types of waste are involved, mixing of the two is advantageous, since only the excess, acid or alkali will require further neutralization. The various acids used in the metal pickling process pose the greatest problems and consist of sulfuric, nitric, phosphoric and hydrochloric acids, with sulfuric being the most commonly used. Quick lime or hydrated lime is the alkaline agent most commonly used. Neutralization is carried out by feeding lime slurry to the spent pickle liquor contained in a tank equipped with an agitator. Lime requirements are obtained from the "acid value" of the pickle liquor and, the "alkaline value" of the lime as determined by chemical analyses. The sludge formed in the process is usually disposed of by lagooning.

SLUDGE HANDLING. Sludge resulting from industrial waste treatment is dried and disposed of by the same means as used for sewage sludge. The method of sludge treatment and disposal used depends on the character of the sludge produced. Organic sludge may be handled by digestion methods used in sewage plants. Drying may be accomplished on open beds or vacuum filters. Industrial wastes containing heavy doses of chemical coagulants produce a large volume of sludge that ordinarily does not dry as rapidly as sewage sludge. Sludge disposal is usually to shallow lagoons or by incineration. Some types of wastes interfere with sludge digestion because of their inhibiting effect on bacterial organisms. Sludge resulting from the treatment of fuels, solvents, oils, and greases may contaminate ground water supplies by seepage if applied to the ground. Care must be exercised that sludge drainage or disposal does not create a new pollution problem. These special aspects of industrial waste sludge handling must be considered in applying the methods commonly used for sewage sludge.

PROCEDURES FOR HANDLING AND DISPOSING RADIOACTIVE WASTES

There may be possibilities where personnel in the Air Force might come in contact with radioactive equipment, materials, and wastes. This condition could exist through the use of atomic power, nuclear weapons, or radioactive equipment and materials. Technical Order 00-110N-2, (Radioactive Waste Disposal) provides information on the disposal of all unclassified radioactive material which has no further use. The use of radioactive isotopes in items of Air Force materials results in radioactive wastes.

The handling procedures for radioactive equipment and materials include:

a. SAAMA as the coordinating agency between field activities and the Air Force disposal contractors.

b. Transportation costs incurred in shipping will be borne by the shipping activity.

c. Land burial of radioactive material by Air Force activities is not authorized except upon specific approval.

d. Segregate radioactive waste from nonradioactive waste.

e. Liquid and solid radioactive materials intended for disposal will be accumulated, stored, and disposed of separately.

PRECAUTIONS. Personnel engaged in any operation involving radioactive materials will observe the practice of personal hygiene. In all cases where a person handling radioactive material receives a cut or skin abrasion the individual will be referred to the nearest medical facility without delay. Radioactive equipment and materials will be monitored during disposition operations. This includes packaging, marking, identifying and shipping.

RADIOACTIVE LIQUID WASTE. Liquid radioactive waste may be discharged into sewers, provided that both the activity of the waste and the volume of dilution water can be accurately measured to assure concentrations are within limits. Authorization for such disposal can only be given by the director of Base Medical Service.

RADIOACTIVE WASTE. This category includes radioactive refuse and items rejected by Redistribution and Marketing. When solid radioactive waste is generated it should be placed in a container which is properly labeled. This container will be covered with a lid and kept free from contamination. The outside of the container will be monitored to insure that radiation intensity levels are not exceeded.

GOOD MAINTENANCE PRACTICE

The disposal of industrial waste requires the use of a good operating sewer system. Unless the sewer system can remove wastes from equipment and materials without interruption, a serious health hazard results. The public investment, the safeguarding of health, and prevention of stream pollution make necessary a program of routine sewer inspections, flushing, cleaning, and immediate location and repair of broken sections. The common practice of cleaning and repairing sewers only when serious objections are encountered is never satisfactory and is more costly than routine maintenance.

Sanitary Sewers

General inspections are required of the entire sewer systems to establish schedules for repairs. Special storm inspections are necessary to find points of excessive infiltration by tracing flow progressively upstream through the system. Outside grease traps are checked for proper removal of grease and effective cleaning of traps. This includes removal of sand, grit, or organic material from basin bottoms. Traps at motor repair shops, filling stations and hangars are checked for proper removal of oil, gasoline and grit.

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Storm Sewers

Special storm sewer inspections should be made during or immediately after a severe storm. The inspection includes storm sewer inlets and catch basin for adequacy of water collection and presence of accumulated debris.

Industrial Waste Sewers

The general inspections of the industrial waste sewers are similar to those of the sanitary sewer systems. The flush and check system include inspections for sluggish flow and evidence of deposits or obstruction. These obstructions should be flushed as often as required to keep sewer clear. The waste flow at upper ends and flat grades should be checked for sluggish movement. The cleaning process includes removal of accumulated solids which allows an increase in rate of flow.

SUMMARY

Industrial wastes at Air Force installations result mainly from metal plating, aircraft, and vehicle washing, cleaning of equipment, and laundry operations. Some of the wastes include cyanides, chromium compounds, acids, alkalies, organic solvents, and products of radioactive materials. Modifications of treating wastes are sometimes required because of different state water pollution laws.

The hazards involved in untreated wastes are fire and explosion, toxicity, interference with steam purification, and odor, sight, and taste nuisances.

Surveys in industrial and radioactive wastes are necessary to determine the source, character, and volume. This provides improvement in plant operation and helps avoid water pollution. Accurate sampling is required for correct analysis of wastes. The types of samples are representative, grab and composite. Samples are tested for BOD, pH, DO, total solids, temperature, color, turbidity, oil and grease.

Three general types of treament can be applied to industrial waste: physical, biological, and chemical. Combinations of these types may be required in specific situations.

Disposal of radioactive waste must be accomplished in a manner that will not create a hazard. Liquid waste may be disposed in sanitary sewerage systems but should not be discharged into a body of water that is to be used as a water supply. If the contaminated waste is solid, it should be buried in the earth or placed in proper containers for disposal. The disposal of radioactive materials must be carried out in accordance with the current directives and under proper supervision.

Workers handling radioactive waste should be kept at a minimum number and protective clothing and equipment should be worn.

Good maintenance practice should be utilized in an efficiently operating sewage plant. This is accomplished by general inspections of sanitary sewers, industrial waste sewers, and storm sewers.

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QUESTIONS

1. Explain the differences between industrial wastes and sanitary sewage?

2. How are cyanide wastes produced?

3. What happens to sewage which comes in contact with excessive concentration of chromium compounds?

4. What is the disadvantage of excessive amounts of acids in the sewage system?

5. How can the pH be controlled when acids and alkalies are fed in the sewer system?

6. What does an organic compound such as phenol do to water supplies?

7. How are phenols and aniline produced?

8. Name some hazards which may exist in untreated wastes.

9. What is the purpose of industrial waste surveys?

10. How is it possible to obtain a representative sample?

11. What tests can be taken from a grab sample?

12. Why is it important to obtain composite samples?

13. Who determines the maximum amount of chemical wastes in water supplies and sewage systems?

14. Why is it important to maintain record on sewage plant operation?

15. Why is it important to reduce waste concentration?

16. What is the most desirable method of treating industrial waste?

17. What compound is used to neutralize acid wastes?

18. What compound will prevent formation of precipitates in industrial waste lines?

19. Name three general types of treatment that can be applied to industrial wastes.

20. What are the handling procedures for radioactive equipment or materials?

21. Why is it important to use good maintenance practice in the disposal of industrial wastes?

22. What general inspections are required of sanitary sewers?

REFERENCES

1. AFM 127-101, Accident Prevention Handbook
2. AFM 85-13, Maintenance and Operation of Water Plants and Systems
3. AFM 85-14, Maintenance and Operation of Sewage and Industrial Waste Plants and Systems
4. TO 00-110N-2, Radioactive Waste Disposal.

WORKBOOKS 3ABR56330-V-2-P1 Thru 10-P1

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Department of Civil Engineering Training

Engineer Environmental Support Specialist

WASTE TREATMENT AND DISPOSAL

March 1972

SHEPPARD AIR FORCE BASE

Designed For ATC Course Use

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WASTE TREATMENT AND DISPOSAL

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This publication supersedes WB 3ABR56330-V-2-P1, 9 September 1970; 3ABR56330-V-3-H1, 1 August 1970; WB 3ABR56330-V-4-P1, 14 September 1970; WB 3ABR56330-V-5-P1, 22 September 1970; WB 3ABR56330-V-6-P1, 15 October 1970; WB 3ABR56330-V-6-P2, 18 September 1970; WB 3ABR56330-V-6-P3, 18 September 1970; WB 3ABR56330-V-8-P1, 17 July 1970; WB 3ABR56330-V-9-P1, 20 October 1970; WB 3ABR56330-V-9-P2, 20 October 1970.

Department Civil Engineering Training
Sheppard Air Force Base, Texas

WB 3ABR56330-V-2-P1
6 March 1972

FIELD SANITATION

OBJECTIVE:

The purpose of this exercise is to aid you in understanding field sanitation.

INSTRUCTIONS

Complete the following exercises:

Use the study guide if necessary.

1. Place an "X" beside the procedures that are used for disposal of waste in isolated and combat areas listed below.

   a. Deep pit

   b. Straddle trench

   c. Secondary treatment

   d. Mound latrines

   e. Bored-hole

   f. Pail or bucket

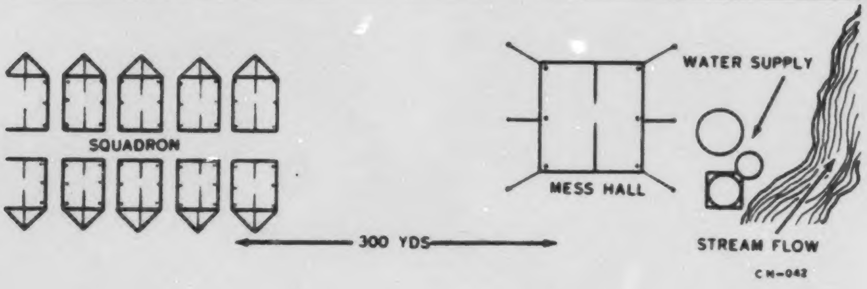
   g. Soakage pits

2. Using the diagram below, indicate with an "X" the best location for a field latrine.

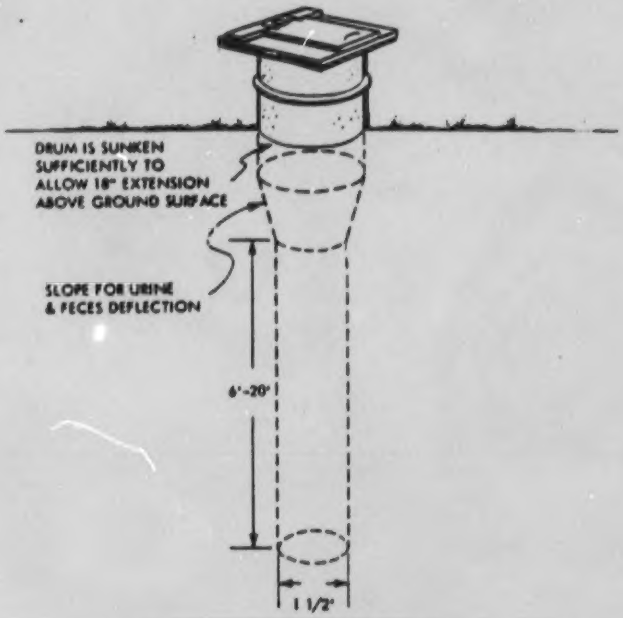
   a. Give your reason for the selected location.

   b. What distance should a field latrine be from quarters?

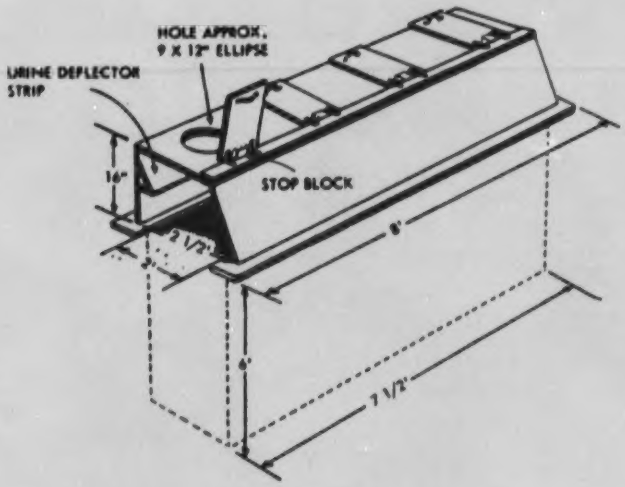
   c. What distance should latrines be constructed from a water supply?



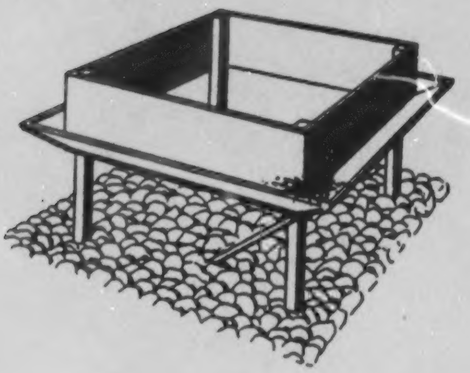
3. Identify the following types of structures shown below.


DRUM IS SUNKEN SUFFICIENTLY TO ALLOW 18" EXTENSION ABOVE GROUND SURFACE
SLOPE FOR URINE & FECES DEFLECTION
6'-20'
1 1/2'

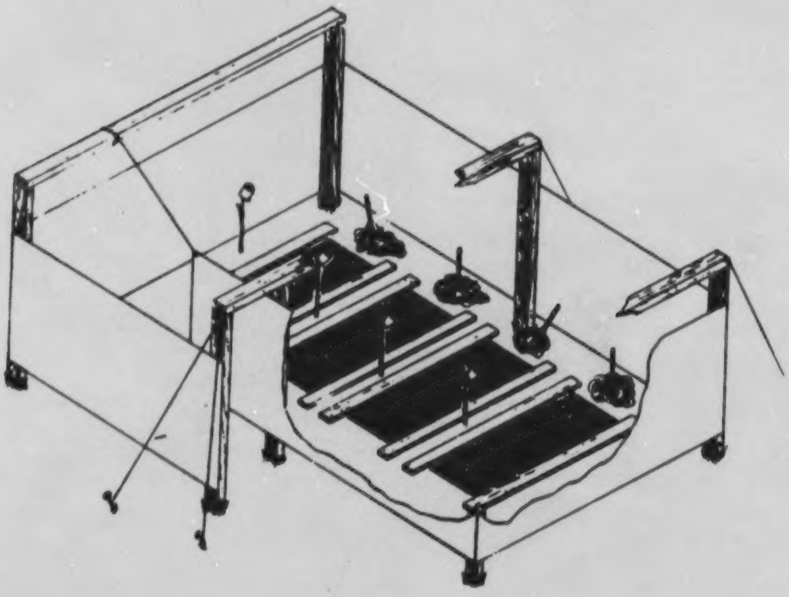
a. ______________________________


HOLE APPROX. 9 X 12" ELLIPSE
URINE DEFLECTOR STRIP
16"
STOP BLOCK
2 1/2'
2'
8'
6'
7 1/2'

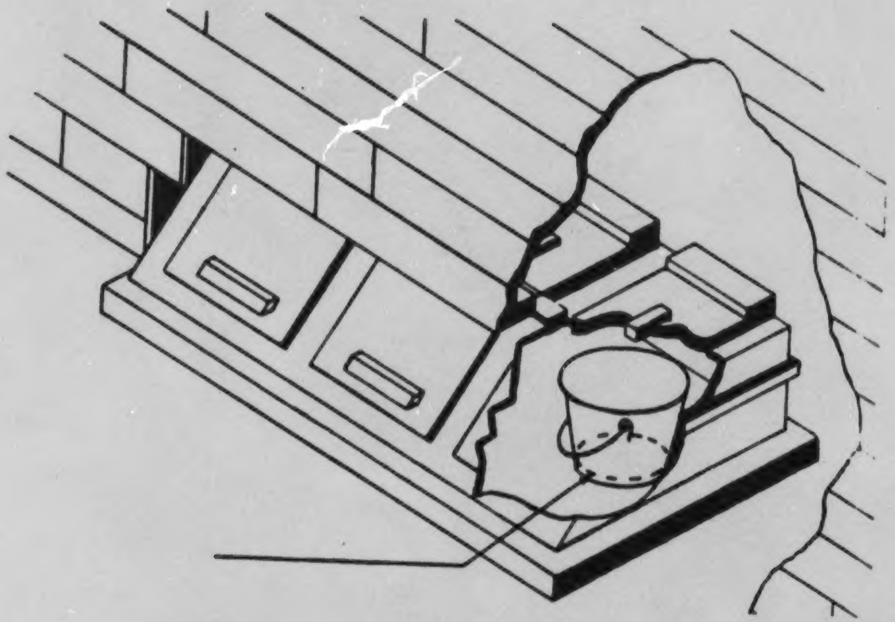
b. ______________________________



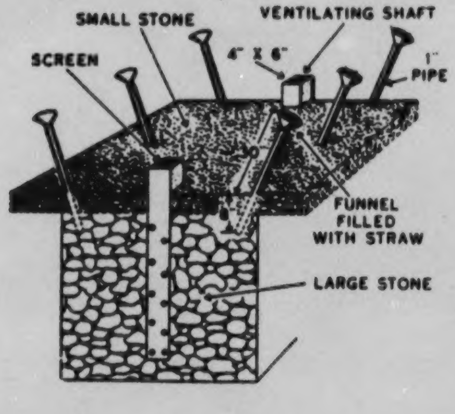
c. ____



d. ____



e. ______________________________


SMALL STONE
VENTILATING SHAFT
SCREEN
4" X 6"
1" PIPE
FUNNEL FILLED WITH STRAW
LARGE STONE

f. ______________________________

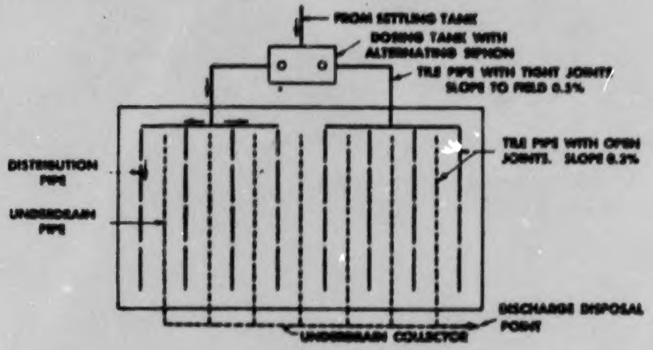
4. List methods for chemically treating field waste.

   a. ______________________________

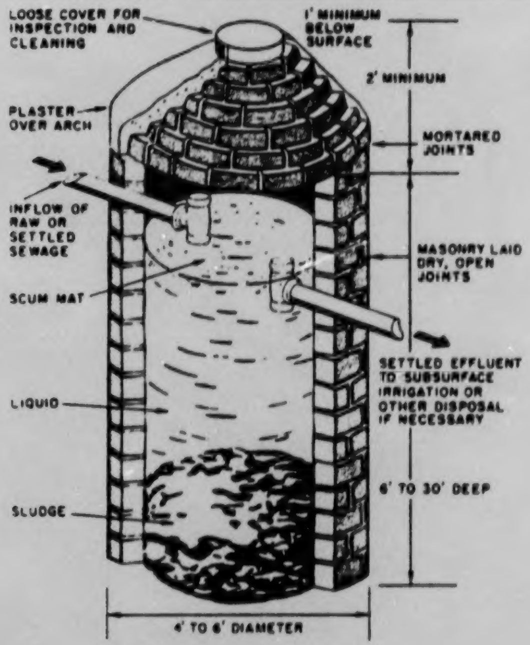
   b. ______________________________

   c. ______________________________

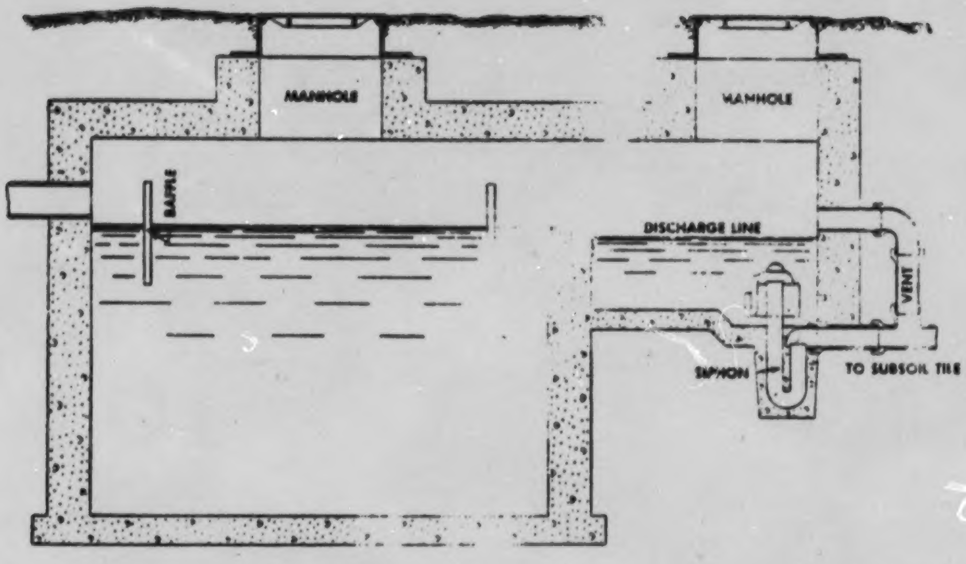
5. Identify the following structures, shown below.


FROM SETTLING TANK
DOSING TANK WITH ALTERNATING SIPHON
TILE PIPE WITH TIGHT JOINTS SLOPE TO FIELD 0.3%
TILE PIPE WITH OPEN JOINTS. SLOPE 0.3%
DISTRIBUTION PIPE
UNDERDRAIN PIPE
DISCHARGE DISPOSAL POINT
UNDERDRAIN COLLECTOR

   a. ______________________________


LOOSE COVER FOR INSPECTION AND CLEANING
1' MINIMUM BELOW SURFACE
2' MINIMUM
PLASTER OVER ARCH
MORTARED JOINTS
INFLOW OF RAW OR SETTLED SEWAGE
MASONRY LAID DRY, OPEN JOINTS
SCUM MAT
SETTLED EFFLUENT TO SUBSURFACE IRRIGATION OR OTHER DISPOSAL IF NECESSARY
LIQUID
6' TO 30' DEEP
SLUDGE
4' TO 6' DIAMETER

   b. ______________________________


MANHOLE
MANHOLE
BAFFLE
DISCHARGE LINE
VENT
SIPHON
TO SUBSOIL TILE

c. ______________________________

6. For what percent of a unit should latrine space be provided?

____

7. In trough type urinals, how many feet are provided for each man?

____

8. What is the difference between an otway pit and other latrines?

____

9. How is sludge removed from septic tanks?

____

10. What is the minimum size for septic tanks?

____

SEWAGE TERMS AND DEFINITIONS

Aerobic bacteria - bacteria which require oxygen for growth.

AFM 85-14 - Maintenance and Operation of Sewage and Industrial Waste Plants and Systems. The manual explains sewage treatment and equipment maintenance.

Algae - small plants, resembling moss or slime, that grow in water. They are undesirable in water systems.

Anaerobic bacteria - bacteria that do not need oxygen to survive.

B.O.D. (Biological-Oxygen-Demand) - the amount of oxygen used in the oxidation of organic matter.

C.F.S. - cubic feet per second.

Detention Time - the period of time from when the sewage enters a tank until it leaves the tank.

Digestion - the breaking down of waste to a more stable form by bacteria.

Digested Sludge - sludge that has been stabilized enough through anaerobic decomposition to permit handling without any nuisance.

10. Dissolved Oxygen (D. O.) - gaseous oxygen dissolved in water. Without dissolved oxygen in water all fish life would die.

11. Effluent - outlet of a plant or from any piece of equipment.

12. Elutriation - a process of successive washing or decanting with fresh water to lessen the concentration. Normally used to reduce the demand for conditioning chemicals.

13. Facultative Anaerobic - bacteria that adapt to growth in either absence or presence of oxygen.

14. G.P.M. - gallons per minute.

15. Grit - inorganic matter such as sand, gravel, rock, etc.

16. High Rate - a trickling filter operated at a high average daily dosing rate, usually between 10 mgd to 30 mgd per acre.

17. Inorganic - material that has no life or has never had life, such as dirt, rock, minerals, etc.

18. Leaching - the disposal of a liquid through a porous material. Example: cesspools draining down by water seepage into the soil.

19. Liquor - a mixture of activated sludge and sewage in the aeration tank undergoing activated sludge treatment.

20. M.G.D. - million gallons per day.

21. Organic - any matter having had life such as skin, vegetable material, and foods.

22. Pathogenic - bacteria that cause diseases.

23. Putrefaction - biological decomposition of organic matter with the production of ill-smelling products.

24. Raw Sludge - a collection of solids in a tank before any treatment has been given.

25. Saprophytic - bacteria which live on dead organic matter.

26. Scum - floating matter such as grease, oil, and froth (suds).

27. Septic - sewage undergoing putrefaction under anaerobic conditions, foul smelling.

28. Stale Sewage - containing little or no oxygen but has no foul smell.

29. Supernatant - the liquid between the sludge on the bottom and the scum on the top in a digester.

30. Zooglea - a jelly-like substance made by bacteria. It is usually associated with activated sludge growths in biological beds.

PRIMARY TREATMENT

Primary treatment consists of the following:

1. Grit Chambers
2. Bar Screens
3. Comminutor
4. Primary Settling Tanks
5. Imhoff Tanks
6. Clarigesters
7. Digesters
8. Sludge Disposal Facilities

SECONDARY TREATMENT

1. Oxidation Ponds
2. Trickling Filter Process
3. Activated Sludge Process
4. Contact Aeration Process

PRINCIPLES OF WASTE TREATMENT

OBJECTIVE

The objective of this workbook is to aid you in gaining a better understanding of the principles involved in waste treatment.

INSTRUCTIONS

Find a term in the right hand column which best fits each descriptive phrase in the left hand column, then place the letter preceeding the selected term in the blank preceeding the descriptive phrase.

1. _____ Aids in removal of large floating objects carried by sewage stream
2. _____ Aids in removal of sand, gravel, heavy solids, razor blades, etc.
3. _____ Shreds large sewage particles and returns them to the sewage system
4. _____ Condition of sewage producing putrefaction
5. _____ A device used to measure the rate-of-flow of sewage entering sewage plant
6. _____ A combination settling tank and digester
7. _____ Type of sewage which settles to the bottom of the primary settling tank
8. _____ Treatment which removes and treats settleable solids
9. _____ Treatment given to liquid portion of sewage remaining after removal of settleable solids

a. oxidation pond
b. contact aeration
c. chlorination
d. trickling filter
e. an aerobic bacteria
f. primary treatment
g. Imhoff tank
h. septic
i. grit chamber
j. bar screen
k. comminutor
l. Parshall flume
m. settleable solids
n. secondary treatment

10. _____ Decomposition of sewage solids in the absence of air

11. _____ The type of bacteria which thrive in well aerated sewage

12. _____ Bed of graded rocks on which Zoogleal film develops

13. _____ Last unit in the secondary treatment

14. _____ Method of disinfecting plant effluent

15. _____ Additional treatment recommended where secondary effluent is to be utilized for industrial purposes

16. _____ Zoogleal film developed on plates in aeration tank

17. _____ Secondary treatment based on return of solids from final settling tank to aeration tank

18. _____ Most nearly duplicates natural stream pruification process

19. _____ Biochemical oxygen demand

20. _____ Sanitary sewage contains mostly

o. aerobic bacteria

p. final settling tank

q. tertiary treatment

r. activated sludge

s. organic matter

t. B.O.D.

PRIMARY WASTE TREATMENT EQUIPMENT

OBJECTIVE

The purpose of this exercise is to aid you in the operation of the sewage trainer located in Room 23, Bldg 939.

NOTE: The trainer can be operated for primary and/or primary and secondary treatment of sewage. The primary treatment can either be by the use of the imhoff tank system or by the primary settling tank system in conjunction with the digester.

INSTRUCTIONS

Using the schematic of the sewage trainer, adjust the necessary valves and components to direct the flow for the following treatment processes. Write down the valve number and component letters and indicate by a check mark whether they are in the closed or opened position.

1. Primary treatment using comminutor and imhoff system.

VALVE NUMBER	OPEN-CLOSE		COMPONENT	OPEN-CLOSE	

2. Primary and secondary treatment using the bar screen and the separate primary settling tank.

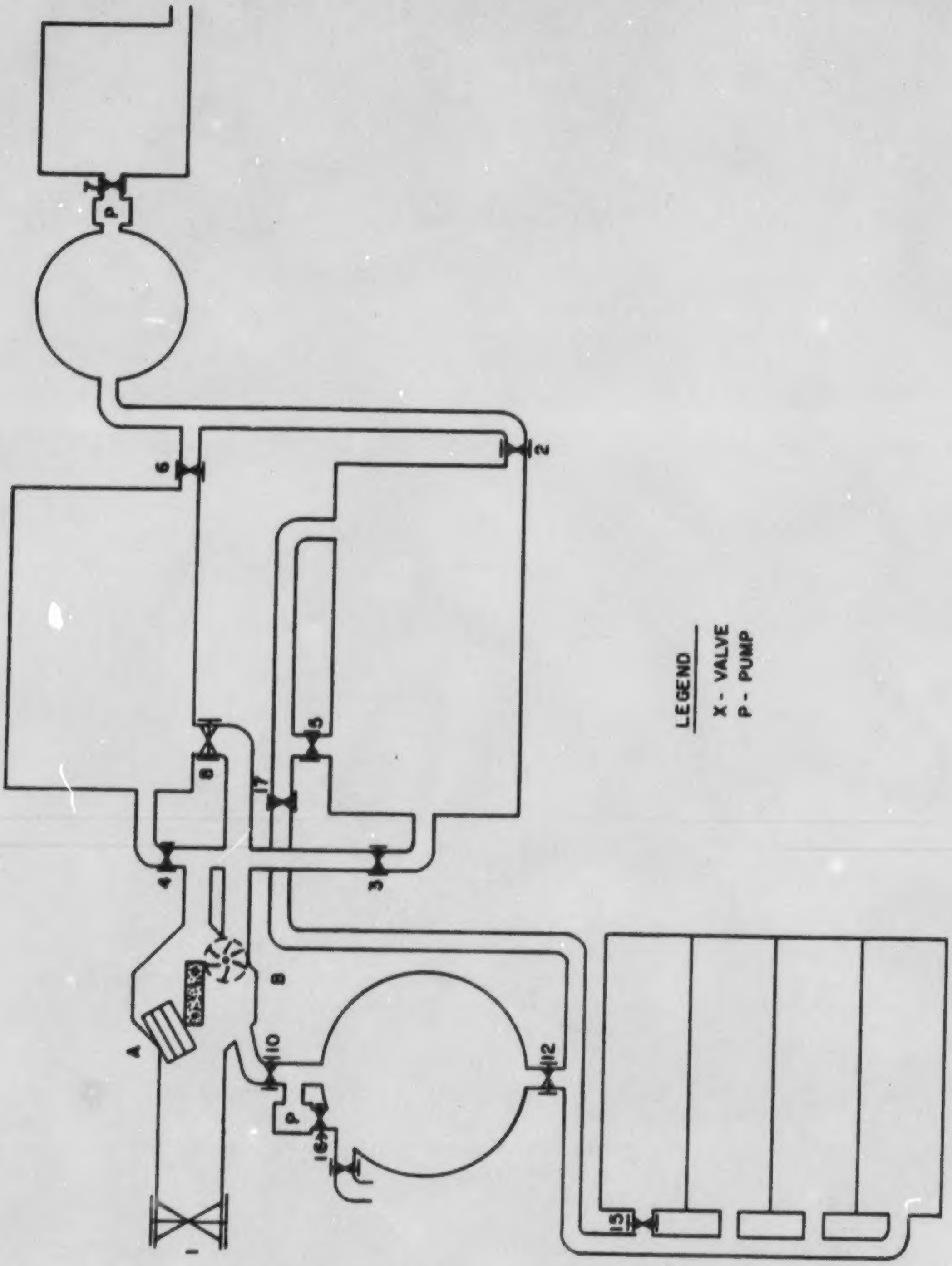
VALVE NUMBER	OPEN-CLOSE		COMPONENT	OPEN-CLOSE	

3. Draw sludge from the imhoff tank to drying bed.

VALVE NUMBER	OPEN-CLOSE	

4. Recirculate sludge in digester

VALVE NUMBER	OPEN-CLOSE		COMPONENT	OPEN-CLOSE	


P
B
A
P
LEGEND
X - VALVE
P - PUMP

SECONDARY WASTE TREATMENT

OBJECTIVE

The purpose of this exercise is to aid you in learning secondary waste treatment; including dosing siphons, trickling filters, and oxidation ponds.

INSTRUCTIONS

Find a term in the right-hand column which best fits each descriptive phrase in the left-hand column; then place the letter proceeding the selected term in the blank following the descriptive phrase.

1. Rotary filters are designed ______________.
2. Fixed nozzle filters are _____.
3. The filter depth is generally ______________.
4. The size of the crushed rock is ____________.
5. The proper dosing of filters is controlled by_________________.
6. Uniform application is controlled by _________________.
7. Natural air movement in cold weather is ______________.
8. Natural air movement in warm weather is ____________.
9. The aerofilter is designed to dose the entire filter bed ______________.

a. 3 to 8 feet.
b. 2 to 4 inches.
c. round in shape.
d. rectangular in shape.
e. nozzles, orifices, and discs.
f. dosing siphons.
g. continuously.
h. up through the bed.
i. each shift.
j. down through the filter.
k. biochemical oxygen demand (BOD).
l. copper sulfate.
m. hot climate.
n. control mosquito breeding.
o. oxidation pond.
p. dissolved oxygen (DO).
q. constructed shallow.
r. lagoons or holding tanks.

10. Following the high rate trickling filter, the final settling tank sludge should be removed at least

    ________________.

11. Trickling filters have a

    tendency to reduce _________.

12. The control of algae may be

    accomplished by using

    ____________________.

13. Oxidation ponds are some-

    times called ___________.

14. For more surface area to be exposed to the atmosphere and sunlight, oxidation

    ponds are _____________.

15. Oxidation ponds operate best

    in dry _______________.

16. Keeping shorelines clean and raising and lowering the water level every 10

    days helps _____________.

17. If ponds are properly operated, there will be

    an increase of ___________.

18. May not have an outlet

    _____________.

CONFIGURATION AND OPERATION OF ACTIVATED SLUDGE SYSTEMS

OBJECTIVE

The purpose of the exercise is to aid you in learning the construction and operation of activated sludge systems.

INSTRUCTIONS

1. Study figure 1 and place the appropriate corresponding number listed below the illustration in the circle provided.

2. Complete the following statements, using Study Guide 3ABR56330-V-6.

   a. What type of bacteria is used in activated sludge process?

   ____

   b. List two types of aerators used in aeration tanks.

   ____

   ____

   c. Aeration utilizing diffused air are designed for a detection of

   ____________ hours and mechanical ____________ hours.

   d. List five characteristics of activated sludge.

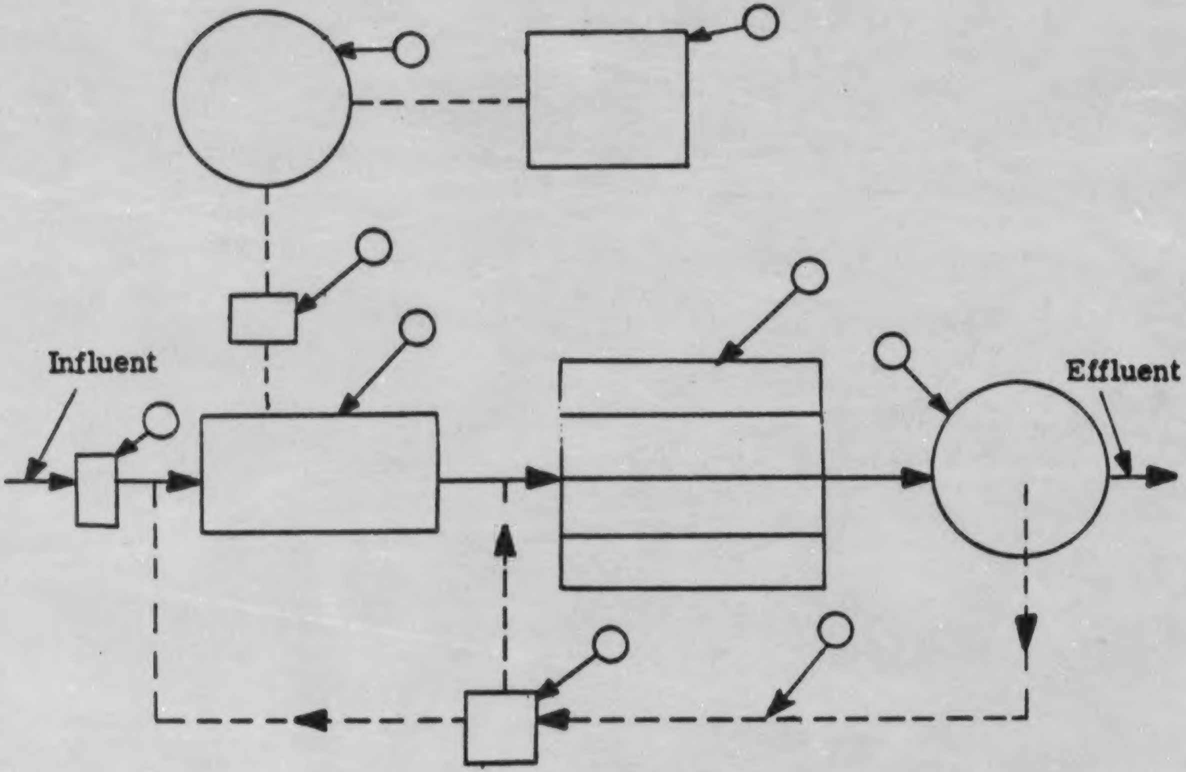
   ____

   ____

   ____

   ____

   ____



MAJOR COMPONENTS

1. Sludge Pumps
2. Aeration Tanks
3. Pretreatment Units
4. Sludge Disposal
5. Final Settling Tank
6. Primary Settling Tank
7. Digestion Tank
8. Return Sludge Line

Figure 1. Flow Diagram of Activated Sludge Process

e. List three conditions which would cause bulking.

f. List five factors that determine the efficiency of an activated sludge plant.

g. Describe the activated sludge process.

h. Compute the following sludge index: If sludge settles to 30% volume in 30 minutes with aeration solids at 1,000 p.p.m. (0.1%), what is the sludge index?

i. List three effects that digester supernatant will have on an activated sludge plant.

____

____

j. Complete the phrases on the left by placing the letters on the right in the space provided.

(1) 95 to 98% air in the diffused aerator is used to ________ .

(2) Detention time for the diffused air system is __________.

(3) 2% of air is used to _______.

(4) Detention time for mechanical aeration is ___________.

(5) The returned sludge is controlled by __________.

(6) Sludge is returned from secondary settling units by ______________.

a. Mix and keep contents in motion

b. Gravity and pumps

c. 8 hours

d. Oxidize the sludge

e. 12 hours

f. Weir boxes and orifices

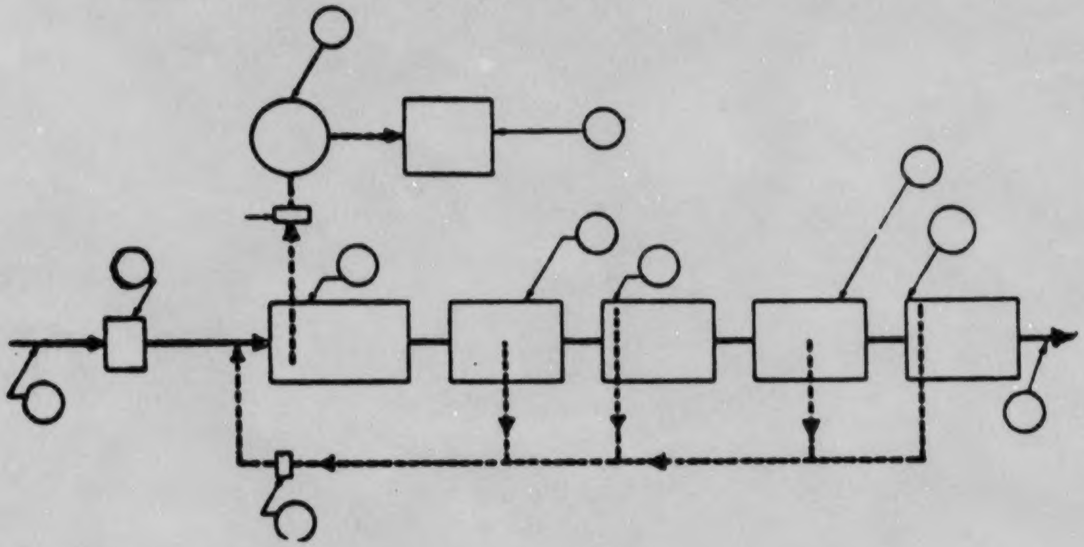
PRINCIPLES AND CONFIGURATION OF CONTACT AERATION SYSTEMS

OBJECTIVE

The purpose of this exercise is to better acquaint you with the operational methods employed in the contact aeration method of sewage treatment.

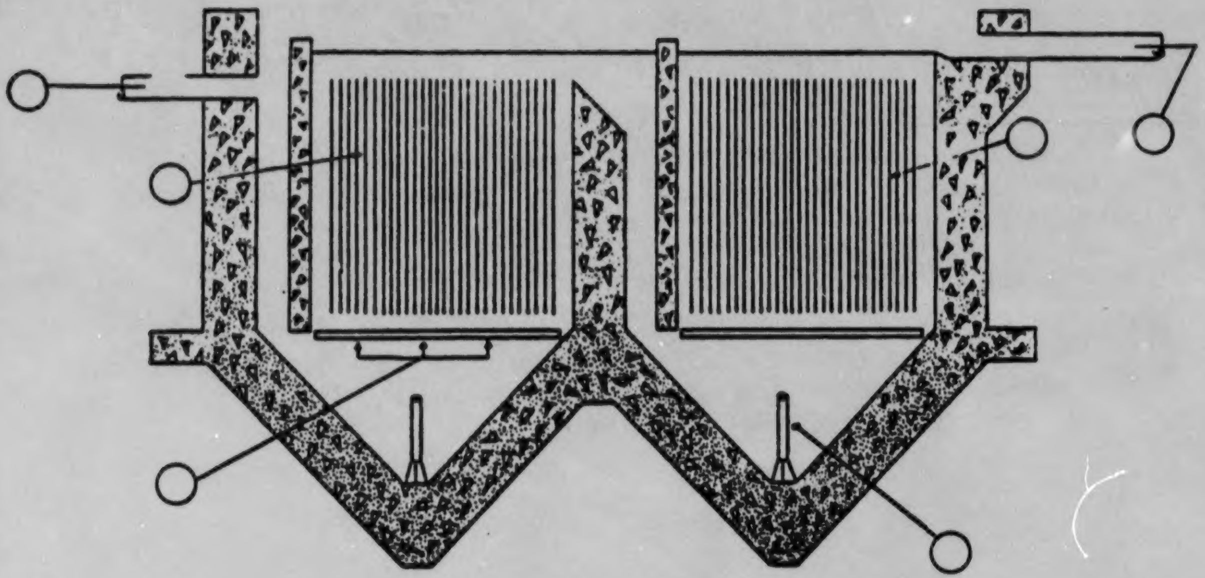
INSTRUCTION

1. Study the illustrations of the contact aeration plant flow diagram in figures 1 and 2, and place the appropriate number from the given list of components in the circles provided.



1.	Pretreatment Units	6.	Sludge Pumps
2.	Influent	7.	Effluent
3.	Digestion Tank	8.	Primary Settling Tank
4.	First-Stage Aeration	9.	Final Settling Tank
5.	Second-Stage Aerator	10.	Intermediate-Settling Tank
		11.	Sludge Disposal

Figure 1. Flow Diagram of Contact Aeration Plant



MAJOR COMPONENTS

1. Sludge draw off
2. Contact plates
3. Air-grid system
4. Influent
5. Effluent

Figure 2. Single-Stage Section of Contact Aerator

2. Use your study guide 3ABR56330-V-6 to complete the following phrases or questions.

   a. Contact aeration is basically what type process? ______________

   ____

   b. Describe the contact aeration process in your own words.

   ____

   ____

   ____

c. Compare the biological action in contact aeration units to that of trickling filters. ______

______

d. What happens in contact aeration units if dissolved oxygen is lost? ______

______

e. List four factors that contribute to its effective operation.

(1) ______

(2) ______

(3) ______

(4) ______

f. Why must grease, scum, floating and suspended solids be removed before entering aerator? ______

______

______

g. Denote what oxidizing power each of the following colors have:

(1) Brown ______

______

(2) Black ______

______

h. Describe what is happening in contact aeration unit if you smell an odor of hydrogen sulfide. ______

______

i. What tests should be made on effluents from contact aeration units? ____________________

____

____

j. What is the medium normally used in the aeration process to hold the bacteria slime? ____________________

____

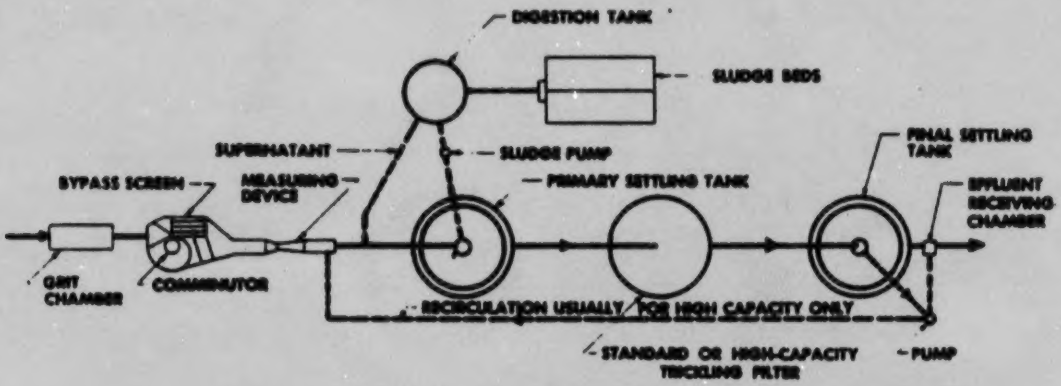
____

CHLORINATION AND STREAM SURVEY

OBJECTIVE: To further your understanding in uses of chlorination and need of water samples in making stream surveys.

IDENTIFYING USES FOR CHLORINATION AND STREAM SURVEY

Look at the schematic below, then answer the following questions:


DIGESTION TANK
SLUDGE BEDS
SUPERNATANT
SLUDGE PUMP
FINAL SETTLING TANK
BYPASS SCREEN
MEASURING DEVICE
PRIMARY SETTLING TANK
EFFLUENT RECEIVING CHAMBER
GRIT CHAMBER
COMMINUTOR
RECIRCULATION USUALLY FOR HIGH CAPACITY ONLY
STANDARD OR HIGH-CAPACITY TRICKLING FILTER
PUMP

1. On the schematic above place a PrC at the point where prechlorination would be applied. ______________________________

2. Approximately how many PPM dosages would you suggest using for prechlorination? ______________________________

3. Under what conditions would you suggest using prechlorination? _____
____
____
____

4. On the schematic above place an IP at the points where an in-plant dosage of chlorine could be used. ______________________________

5. What is your reason (s) for selecting the site (s) for in-plant dosage?

6. What dosage would you suggest using at the site or sites you selected?

7. On the schematic place a PoC at the point where post chlorination would be applied.

8. How much contact time should be allowed after post chlorination before discharging the effluent into a stream?

9. How can it be determined how much chlorine is needed during post chlorination?

10. In what manner does a high BOD affect a stream?

11. BOD is normally more harmful to a stream during which part of the year?

12. For a stream survey how many sampling locations would you select?

13. List the sampling locations.

14. Why is the temperature of the stream needed during a stream survey?

INDUSTRIAL WASTE TREATMENT

OBJECTIVE

The purpose of this project is to aid you in understanding industrial waste treatment.

INSTRUCTION

Using Study Guide 3ABR56330-V-9, complete the following questions and fill in the blanks.

1. What types of wastes are included in industrial wastes? ____________

____

2. What Air Force regulation governs the treatment and disposal of industrial waste? ______________________________

3. List four types of hazards involved with industrial wastes.

   a. ____

   b. ____

   c. ____

   d. ____

4. List five types of wastes that are of primary interest to the Air Force.

   a. ______________________

   b. ______________________

   c. ______________________

   d. ______________________

e. ____________________

5. What is the maximum allowable concentration of the following?

   a. Hexavalent chromium ____________________

   b. Lead ____________________

   c. Copper ____________________

   d. Zinc ____________________

   e. Phenal compounds ____________________

   f. Sodium hydroxide ____________________

6. Why are industrial waste surveys important? ____________________

   ____

7. List three methods of collecting industrial waste. Explain each method.

   a. ____

   ____

   b. ____

   ____

   c. ____

   ____

8. What type of materials is used to construct sewers for industrial wastes? ________________________________

   ____

9. List the three general types of waste treatment. Explain each type.

   a. ____

   ____________________ ~~326~~ ____________________

b. ____________________

____

c. ____________________

____

10. How is sludge from industrial wastes disposed of? ____________________

____

____

11. What is the average g.p.m. flow from aircraft wash racks? Peak flow? ____________________

12. What type of treatment is used to treat the combination of wastes from aircraft wash racks, engine repair shops, and engine test cells?

____

13. Explain the operation of an ion exchanger in the recovery of chromates. ____________________

____

____

14. Describe the biological oxidation process in the treatment of phenal wastes. ____________________

____

15. Describe the batch treatment method used to treat cyanide.

____

____

____

Checked by ____________________
Instructor

RADIOACTIVE CONTAMINATION

OBJECTIVE

The purpose of this workbook is to aid you in becoming familiar with procedures for radiological disposal.

INSTRUCTIONS

Complete the following questions and phrases using Study Guide 3ABR56330-V-9.

1. Why is it necessary to be aware of the hazards of radiological disposal?

   ____

   ____

2. How can radioactivity in waste be reduced? ______________

   ____

3. How should radioactive wastes be discharged into a sewage system?

   ____

   ____

4. List three precautions that must be checked before radioactivity wastes can be discharged into a sewerage system.

   a. ______________________________

   b. ______________________________

   c. ______________________________

5. List three methods that may be used to treat radioactive wastes.

   a. ______________________________

b.

c.

6. List two methods of disposing of solid radioactive wastes.

a.

b.

7. How should an area containing radioactive waste be identified?

8. Who supervises the disposal of radioactive waste?

9. What records are maintained on personnel exposed to radioactive waste? By whom?

10. What technical order prescribes the procedures for safe disposal and and limits of radioactive wastes?

11. What precaution should workers exercise while working around radioactive wastes?

12. When discharging radioactive wastes in sanitary sewers, what records must be kept? ______________________________

____

Checked by ______________________
Instructor

SAFETY PRACTICES

OBJECTIVE

The purpose of this exercise is to aid you in understanding some of the common safety practices you will be expected to observe during job performance.

INSTRUCTIONS

Complete the following statements by entering the correct information in the blank spaces.

1. Unsafe acts of people cause __________ percent of all accidents.

2. AFM 127-101 states that no one male person should lift more than ____________________.

3. Working areas should be kept ____________________ at all times.

4. When using hand tools, the force should be exerted __________________ the body.

5. To help prevent slippage, a wrench handle should be __________________ not ____________________________.

6. Electrical power tools should always be ____________________________.

7. ____________________________ account for about one in every five hand tool accidents.

8. Never hold a piece of material by hand and attempt to _______________ it with an ____.

9. When loading an elevator, the _______________________ should be known.

10. Never wear a __________________ hard hat around electrical hazards.

11. Safety color code:
    a. Blue would indicate ________________________ ________________.
    b. Red would indicate ____.
    c. Green would indicate ____.

12. ____________ ______________ is essential in the effective prevention of fires.

13. ______________ is the "killer" in the case of electrical shock.

14. For combating electrical fires, a ______________ type fire extinguisher is recommended.

15. ________________ should never be given to a person who is unconscious or has a belly wound.

16. A ________________________________ is a broken bone with a break in the overlying skin, with the broken bone protruding.

17. Severe burns usually cause ______________________________.

18. The most important thing to remember in giving artificial respiration is ____.

19. Do not move an injured person unless ________________________.

____.

20. Define the three classes of fire and list the applicable fire extinguishers.

Type of Fire	Definition	Extinguishers Used
Class A:		
Class B:		
Class C:		

315

STUDY GUIDE AFS 54, 55, and 56

17-6

7

Department of Civil Engineering Training

All Courses

SAFETY

20 January 1975

SHEPPARD AIR FORCE BASE

75-5-30

Designed For ATC Course Use

DO NOT USE ON THE JOB

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  FIRES AND FIRE PREVENTION 6

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Dept of Civil Engineering Tng
Sheppard AFB, Texas

SG AFS 54, 55, and 56
20 January 1975

SAFETY

OBJECTIVE

To present information on some of the hazards present in accomplishing your duties as a member of the Air Force and the prescribed safety procedures to avoid personnel injury or equipment damage.

INTRODUCTION

As an Air Force specialist or technician, you should have two primary aims in life: one, to do a first-class job in your assigned duty; the other, to return to civilian life, either by discharge or retirement, in as good a physical condition as possible. A thorough knowledge of the hazards confronting you, the established safety rules to protect you, and your observance of these safety rules, may determine what condition you will be in when you return to civilian life. In fact, it could determine whether or not you live long enough to become a civilian again.

The objective of this study guide is to help you prevent injury or death to yourself or to your fellow worker, and to prevent damage or destruction of Air Force equipment. The valuable information pertaining to the objective will be presented in five sections as follows:

- SECTION I - GENERAL GROUND SAFETY
- SECTION II - NUCLEAR SAFETY
- SECTION III - RADIATION SAFETY
- SECTION IV - FIRST AID
- SECTION V - SAFETY AND HUMAN RELIABILITY PUBLICATIONS

SECTION I

GENERAL GROUND SAFETY

General items of safety apply to just about all duty assignments within the Air Force. To help you become more aware of the need for proper safety practices, and to help you survive in a challenging world, important information is presented in the following topics of this section:

- ACCIDENT CAUSES
- WORK AREA SAFETY PRACTICES
- FIRES AND FIRE PREVENTION
- ELECTRICAL HAZARDS AND SAFETY PRACTICES
- SAFETY EQUIPMENT

This supersedes SG AFS 54, 55, and 56, 25 February 1972.

ACCIDENT CAUSES

A standard dictionary defines the word "accident" or "accidental" as, "An event that takes place without one's foresight or expectation." This definition indicates that with adequate foresight, most of our accidents can be prevented. They can. Refer to Figure 1 for a graphic representation of the underlying causes of accidents.

Often when another person is involved in an accident of one kind or another, we can readily see how he could have avoided it. This is because there are certain things or conditions which cause accidents. All we must do to prevent most accidents is be able to recognize the causes and apply the appropriate preventive measures. The following topics will present some common causes of accidents and the action to take to eliminate these causes.

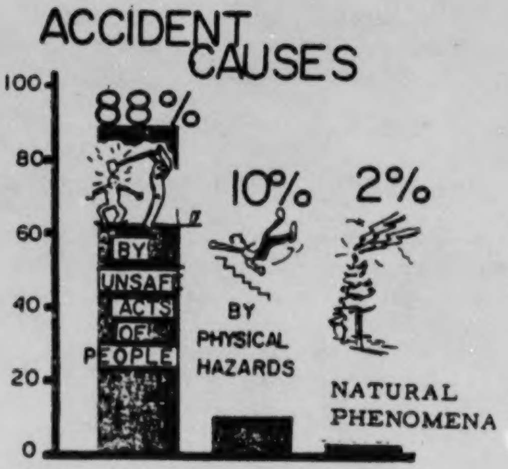


Figure 1. Causes of Accidents

WORK AREA SAFETY PRACTICES

Your work area may contain many potential hazards if you fail to follow the safety rules established for your protection. The following paragraphs will make you conscious of some of the things you should, or shouldn't do, to perform your job safely.

Housekeeping

Poor housekeeping, that is not keeping your work area clean and orderly, can result in various types of accidents both of a major and minor nature. Broken bones, cuts, gouges, bruises, burns, and many other injuries can result from poor housekeeping. The prevention of these injuries is simply to practice good housekeeping. Some of the important items to consider in keeping your working area, and also your living area, in proper order are given below.

- Keep all floors and walkways clean, dry, and free from spilled oil, fuel, or other contaminates. If fuel, oil, or grease is spilled, clean it up immediately. Slipping and falling could result in a serious injury to you or someone else.

- Insure that your plant or other area is adequately ventilated at all times. Vapors from fuels, oils, greases, and various types of acids are injurious to your health.

- Keep all working areas well lighted if at all possible. You cannot work efficiently and safely without sufficient lighting. Check the lighting system frequently and replace burned out lamps, fuses, and accomplish other preventive maintenance as required.

- Don't leave tools scattered about on floors, engines, work stands, or any other place other than those cabinets and boxes especially provided for tools. Some tools used in maintenance are heavy enough to cause considerable damage by falling a short distance.

- Don't struggle with a tool box which is too heavy to handle conveniently. Men have been known to rupture themselves in handling excessively heavy tool boxes. Divide your tools so that you can handle them without strain.

- Don't clutter your work area with unnecessary equipment. If you do not intend to use an item, store it in a safe place.

- Keep all ropes, chains, cables, hoses, and electrical extension cords properly stowed when not in use.

- Provide suitable waste containers for waste and insure that waste is promptly put into the proper container. Mark each container for the material it is to be used for.

- Use extra care in disposing of scrap metal, tubing, wire, glass, etc. Insure that all parts of the materials are well inside the waste container. The sharp edges of these materials will cut and tear your skin as well as your clothes.

- Maintain an adequate inspection program of all electrical cables, switchgear, and equipment for frayed wiring insulation, exposed contacts, and condition of switch handles and other controls.

- Inspect your shop frequently for protruding nails, bolt ends, and other sharp points which may cause injury. Also insure that broken window and door glasses are replaced promptly and the broken glass properly disposed of.

- Insure that water fountains, lunch areas, and personnel clothing lockers are kept in a clean, sanitary condition. Illness caused by contaminated water, food, coffee, etc., can often become more serious than most accidents.

The above listed housekeeping items are not the only things for you to consider, but they will help you improve your housekeeping situation.

Horseplay

Some of the common varieties of horseplay are pushing, tripping, directing compressed air toward a friend, shocking a friend with electricity, applying the hotfoot, and, perhaps the worst of all, goosing. This goosing, if applied to a nervous person, may cause him to leap into moving machinery or into contact with high voltage electricity, or he may simply fall and "only" break an arm. Injuries or deaths resulting from horseplay cannot be justified. Horseplay in any Air Force shop is strictly forbidden.

Improper Working Methods

Equipment which has exposed moving parts such as belts, chains, flywheels, moving arms, etc., can be a serious safety hazard unless care is exercised during its operation and maintenance. While most moving parts of machinery are enclosed in protective guards of one kind or another, alertness on the part of the operator or mechanic is essential. Gloves, neckties, or loose clothing, particularly large loose sleeves, should not be worn around moving machinery. Just stop for a moment and visualize what would happen if your necktie or even your sleeve should become caught in a drive belt or chain. You would be lucky to escape with your life.

Any adjustment, cleaning, lubrication, or repair of moving machinery should be accomplished with the device stopped if at all possible. If it is not possible to stop the device, extreme care should, and must, be observed to prevent serious injury.

The weight of various heavy parts and tools becomes a potential safety hazard. The Ground Accident Prevention Handbook (AFR 127-101) recommends that objects weighing more than 50 pounds not be lifted by one person. This manual takes into consideration that the object can be lifted in the proper manner. Refer to Figure 2 for the position to assume when lifting heavy objects.

This proper lifting position is important. During many maintenance tasks you cannot assume the proper lifting stance; therefore, the 50 pound limit may be far too high. Don't feel like a sissy when you decide to use a mechanical lifting device to save your back. It is the proper thing to do. Just be sure to inspect the mechanical device for proper operating condition before each use and never exceed its capacity.

The improper use of common hand and power tools results in many avoidable accidents. One of the prime rules in the use of any tool is to use the right tool for the right job. Another prime rule is to keep all tools in a good state of repair. Also keep tools in their proper place so that they can be used when needed. Some important safety items to consider in the use of tools are given in the paragraphs below.

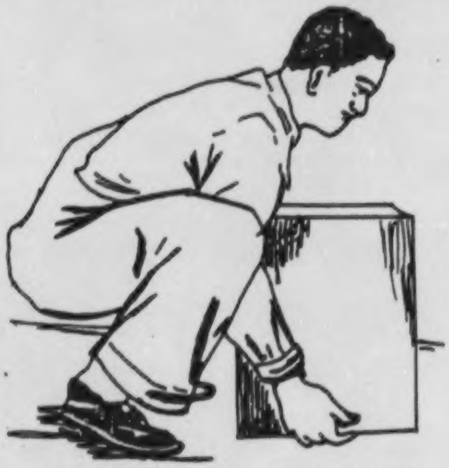


Figure 2. The Right Way to Lift

- When possible, use hand tools so that the working force is always directed away from your body. This will minimize the chances of injury in case the tool should slip.

- When handles of hammers, sledges, files and other tools become splintered or loose, replace them immediately.

- Mushroom heads on cold chisels, punches, drift pins, hammers and other similar tools should be dressed down as soon as they begin to check and curl.

- Cutting tools should be kept sharp and kept in their proper sheaths. They should never be placed in clothing pockets.

- Box end type wrenches or sockets should be used whenever possible. They are less likely to slip than open end and other type wrenches. Another thing, if a job requires a special tool, use a special tool. To help prevent slippage, a wrench handle should be pulled, never pushed.

- Impact goggles or face shields must be worn any time there is danger of flying chips, sparks, or other debris.

- Small parts should always be held securely in a vise while being worked on.

- Since hammers account for about one in every five hand tool accident, care must be observed in their use. Hammer handles should never be used as pry bars and since only the face of the hammer is case hardened, the side of it should never be used as a striking tool.

- Screwdrivers are probably the most used, and the most misused, tool of all. They are designed for only one use. This is to loosen and tighten screws. Blades of screw drivers should be kept ground and dressed at all times, and for each job the proper screwdriver size should be considered. Firm footing must always be established before applying pressure to a screwdriver and objects being repaired should never be held in your hand, or on your lap. The common vise was designed to hold parts securely while being repaired.

- Files and rasps are particularly hazardous to maintenance personnel because of their abrasive surfaces, tanged (sharp pointed) handles, and their brittle construction. Always use them for what they were designed for. Never use them as pry bars, punches, or chisels. Never use a file or rasp without the proper handle installed, you may drive the tang right through your hand.

- Punches and chisels should be kept clean and during use should be held firmly between the thumb and all four fingers.

There are many more safety precautions to observe in the use of hand tools; however, the space here prohibits listing them. It is highly recommended that you refer to the Ground Accident Prevention Handbook (AFR 127-101) often. Frequent use of this manual can save you from many painful injuries.

The use of powered hand tools require generally the same precautions as for non-powered tools, plus additional safety precautions. In the case of electrical tools cleanliness and a good state of repair is of the utmost importance. In addition to keeping the tools and electrical cords in first rate condition, the tool should always be properly grounded during use. This protects the worker against the danger of electrical shock in the event a short circuit occurs within the tool. This need for grounding is often disregarded but it is important and must never be omitted. Another important precaution is to always secure the item being worked on in a vise. Never hold a piece of material by hand and attempt to drill it with an electric drill. The material may catch on the drill bit and become a rapidly spinning blade.

Observe Accident Prevention Signs

Warning signs. Warning signs are posted for one reason only. That reason is to prevent accidents. There may be times when you see an area posted which you do not consider a hazardous area. In these cases just remember that some one had a good reason to post the area, so observe the warning sign.

Standard signs are posted to warn of certain hazards: Danger signs (red) warn of specific dangers only; Caution signs (yellow) warn of possible dangers and unsafe practices; Safety Instruction signs (green) provide information on general safe practices; Directional signs (black and white) indicate the way to stairways, fire escapes, exits, etc.; Information signs (also black and white) carry messages of a general nature.

Here are some of the signs you will see: DANGER HIGH VOLTAGE, DANGER KEEP OFF, DANGER KEEP AWAY, DANGER NO SMOKING, DANGER GASOLINE, CAUTION DO NOT TOUCH SWITCHES, CAUTION MEN WORKING, CAUTION USE GUARD, and many more.

AF Form 1492, "Danger Tag." This tag is blue in color and is designed for use as an important tool in accident prevention; it will be attached, by designated tag-issuing authorities, to material and equipment no longer safe to use because of defects, abuse, or wear. It is not designed or intended for use in reporting minor hazards which should be corrected by the responsible supervisor, and utmost discretion must be used in issuing it. Misuse of the tag will cause it to become common-place, resulting in the loss of its intended value as an effective part of the accident prevention program.

The responsible commander will designate tag-issuing authorities in aircraft maintenance, base engineering, supply, food service, transportation, communication and electronics, medical service, and other Air Force activities. Authorized personnel will attach the tag to unsafe machinery, equipment, tools, electric circuits and devices, pipelines, valves, controls being repaired, workstands, elevators, ladders, power-operated doors, and other unsafe items or conditions incident to work processes in order to prevent employee injury and/or damage to material or equipment. Since an arbitrary tagging of equipment or material may cause needless expense and delay, the tag-issuing authority will not attach a danger tag without notifying the appropriate supervisor of the activity affected. However, if the hazard becomes too great, and the responsible supervisor is not available, the tag-issuing authority will issue the tag and inform the supervisor as soon as possible that he has done so.

AF Form 267, "Electrical Danger - Men at Work." This red tag may be used for blocking and tagging requirements. For example, to work on an item of equipment in sight of its disconnecting device, the disconnecting device would be tagged with a properly filled out AF Form 267.

AF Form 268, "Caution - Abnormal Conditions." This yellow tag may also be used for blocking and tagging. For example, an automatic device switched to manual operation for testing purposes, should be yellow tagged with AF Form 268.

Once the Danger Tag has been attached to a machine or other piece of equipment, the item will not be operated or used until the hazard has been corrected and the tag removed.

FIRES AND FIRE PREVENTION

While fire fighting is the prime responsibility of the area fire department, it is the duty of each individual to do his utmost in preventing fires, and to aid in extinguishing them. This topic will cover the various types of fires and the measures to apply in controlling them.

Fire Prevention

Good housekeeping is essential in the effective prevention of fires. Accumulations of rubbish, waste, dust, and other residue are all sources of fires. One of the most important measures in fire prevention is shown in Figure 3.

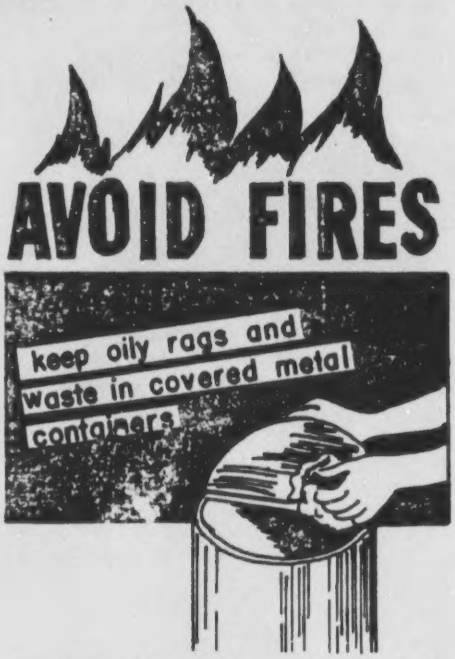


Figure 3. Fire Prevention at Work

Another serious fire hazard is the accumulation of fuel vapors, gases, paint vapors, and other items of this nature. To eliminate this type of hazard, keep your shop clean and well ventilated. Proper inspection and maintenance of equipment will usually correct hazards due to leakage of flammable materials. Generally, all painting should be accomplished in an approved paint shop. When this is not possible, the need for adequate shop ventilation becomes critical. Paint will burn, so will its vapors; therefore, use extreme care when painting with a spray gun. Prevent fires whenever you can, but also know something about fire fighting in event you can't prevent them all.

Classes of Fires

Fires are grouped into four general classes. Fires in each class can be extinguished by the use of a particular action or extinguishing agent. Because all fire extinguishing agents cannot be used on all types of fires, it is necessary to know the various classes of fires and which extinguisher to use for each class.

Class A fires are fires occurring in wood, clothing, paper, rags, and other items of this nature. This type of fire can usually be handled effectively with water. Water provides the cooling and quenching effect necessary to extinguish Class A fires.

Class B fires are those occurring in flammable liquids such as gasoline, fuel oil, lube oil, grease, some solvents, paints, etc. The agents required for extinguishing this type of fire are those which will dilute or eliminate the air by blanketing the surface of the fire. This action creates a smothering effect.

Class C fires are fires in electrical equipment and facilities. The extinguishing agent for this type of fire must be a nonconductor of electricity and provide a smothering effect.

Class D fires occur in combustible metals such as magnesium, potassium, powdered aluminum, zinc, sidium, titanium, ziroconium and lithium. The extinguishing agent for this type fire must be a dry-powdered compound. The powdered compound must create a smothering effect.

In the case of any fire, there are certain actions required of the individual who discovers the fire. His first action should be to sound the alarm and alert all personnel. Second, the installation fire department must be summoned and given explicit directions to the location of the fire. These first two actions must be taken quickly, and after they have been accomplished the personnel available should apply the most effective measures available to extinguish or to contain the fire. To do this, it is essential that you acquire a knowledge of the various types of portable fire extinguishers.

Portable Fire Extinguishers

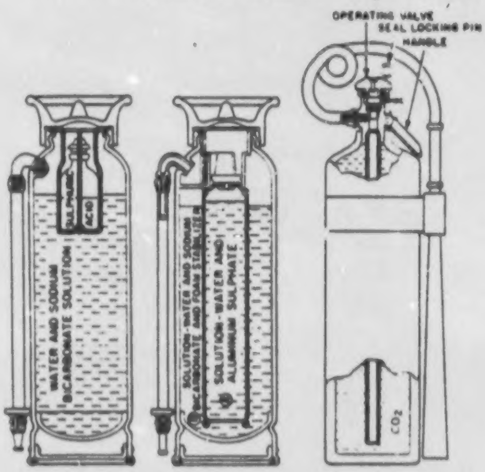
The Pump Tank type portable extinguisher is perhaps the most simple of all. It is simply a water tank with an attached pump. The effective range of this device is only a few feet and it should only be used on Class A fires. To use this extinguisher, simply unhook the hose, direct it to the fire and start pumping. If you use all the water, refill it from the nearest available source and continue its use.

Soda-Acid type extinguishers are also used only on Class A fires. Refer to Figure 4 for the construction features of this type fire extinguisher. The use of the soda-acid extinguisher is also very simple. Simply direct the hose toward the base of the fire and invert the extinguisher. This inversion causes a mixing of the solution inside the tank, a reaction occurs and the solution is supplied to the hose under pressure.

The Foam Type fire extinguisher is also shown in Figure 4. This unit may be used on either Class A or Class B fires. The method of using this extinguisher is the same as for the Soda-Acid type. Invert it and direct the hose so that the foam is layed over the surface of the fire. This is for a fire involving liquids. For a fire in a solid material, the stream of foam should be directed to fall lightly on, or flow over, the burning surface of the material.

Carbon Dioxide or CO_2 type extinguishers may also be used on Class B and on Class C fires. This unit is also shown in Figure 4. To operate the CO_2 extinguisher, pull the seal locking pin and open the operating valve. The CO_2 should be directed toward the base of the fire with a sweeping motion.

Vaporizing Liquid type extinguishers also may be found in some installations. These extinguishers contain a solution of Chlorobromomethane (CBM) or other similar chemical. These units generally incorporate a hand pump for maintaining the discharge pressure and they may be used on Class B and Class C fires. The disadvantages of this type of extinguisher is that they give off a toxic gas during use and therefore should never be used in a poorly ventilated area. When they are used, it is not advisable to remain in the area of use. A safe rule would be not to use this type if another suitable type is available.


OPERATING VALVE
SEAL LOCKING PIN
HANDLE
SULPHURIC ACID
WATER AND SODIUM BICARBONATE SOLUTION
SOLUTION-WATER AND SODIUM BICARBONATE AND FOAM STABILIZER
SOLUTION-WATER AND ALUMINUM SULPHATE
CO2

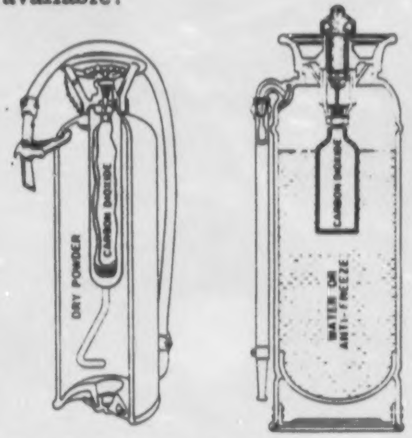
SODA-ACID FOAM TYPE CARBON DIOXIDE

Figure 4. Portable Fire Extinguishers

Dry Chemical type extinguishers may also be used on Class B and C fires. These units contain a dry powder, usually sodium bicarbonate, and an activating agent of CO_2 or nitrogen gas. Refer to Figure 5 for an illustration of the dry chemical extinguisher. These units should not be used on trash fires. To put the extinguisher into use, remove the locking pin, open the cartridge discharge valve and squeeze the nozzle handle.

Figure 5 also shows a gas and water type extinguisher for use only on Class A fires.

There are other types of portable fire extinguishers in use at various installations. For information about these many different devices, refer to the table shown in Figure 6.



DRY CHEMICAL GAS AND WATER

Figure 5. Dry Chemical and Gas and Water Extinguishers

Remember, a stitch in time saves nine. If you can extinguish a fire while it is still small you can in some cases, prevent a major disaster. The only way you can effectively fight fires is to be able to readily classify the fire and know which extinguisher to use in each case. Also you must know how to use each extinguisher.

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First Aid Fire Extinguisher Characteristics

TYPE	AGENT: Fire extinguishing material	How it stops fire	USE: Class of fire	Operating Method	ACTION: What makes it effective	Electrical conductor hazard	Maintenance to prevent freezing	WARNINGS Instructions
Pump-tank .. or Self-Pressure.	Water	Cools, quenches.	A	Manual pump or self-pressure with hose nozzle manipulation.[1]	Pump pressure ... Self-pressure	Yes	Yes [2]	Do not use on electrical fires.
Soda-acid	Solution: Sodium bicarbonate.	Cools, quenches.	A	Invert tank, manipulate nozzle.[3]	CO_2 gas pressure [4].	Yes	Yes [5]	Do not use on electrical fires.
Foam, chemical reaction.	Foam [6]	Excludes air or smothers.	B, A	Invert or hand actuate to fall lightly on or flow over burning material.[7]	CO_2 gas pressure [8].	Yes	Yes [5]	Relatively ineffective on alcohol acetone.[9]
Vaporizing liquid.[10]	Inert gas [11].	Excludes air or smothers.	C, B	Pump or hand actuate.[12]	Hand pump, stored air pressure, or gas cartridge.	No	[13]	Gives off toxic gas when heated. Use care in confined spaces.
CO-TWO [14] ..	([15])	Excludes air or smothers.	C, B	([16])	Self-contained CO_2 gas pressure.	No	No [17]	Extinguishing effect not lasting: flash back may occur.[18]
Dry chemical.	Powder [19] ..	Excludes air or smothers.	C, B	([20])	CO_2 cartridge or nitrogen cylinder.	No	No [21]	Extinguishing effect not lasting: flash back may occur.
Loaded stream.	Liquid [22] ...	Cools, quenches. [23]	A, B	Invert or hand actuate.[24]	CO_2 cartridge or gas from acid-salt reaction.	Yes	No	([19])
Antifreeze ...	Liquid [26] ...	Cools, quenches.	A	Invert or hand actuate. Direct at base of flame.	([27])	Yes	([13])	Do not use on electrical fires.
Water bucket.	Water	Cools, quenches.	A	Direct at base of flame.	Thrown by hand ..	Yes	Yes [2]	Barrels of water may be provided as reservoirs.[10]
Powdered compounds.	([23])	Dilutes or excludes air smothers.	([25]) D	([20])	Thrown by hand or dispensed from cartridge operated cart.	Yes	Yes	([19])

---

[1] Direct stream at burning material.

[2] Add calcium chloride antifreeze solution. Care will be exercised to treat tank or use corrosion inhibitor.

[3] Direct stream at base of flame.

[4] Reaction of soda and sulphuric acid.

[5] Do not add antifreeze chemicals: provide heat.

[6] Stabilized carbonic acid gas bubbles with water carrier.

[7] Do not direct stream into flame.

[8] Reaction of sodium bicarbonate and aluminum sulphate.

[9] Relatively ineffective on alcohol, acetone, and other substances which break down the foam, unless special foam is used.

10 CHLOROBROMOMETHANE AND SIMILAR COMPOUNDS.

[11] Released by special vaporing chemical agents.

[12] Direct stream at base of flame or on sides of container.

[13] Does not freeze at normal temperatures. Different agents have different freezing temperatures. See Manufacturer's instructions.

[14] Carbon dioxide.

[15] Carbon dioxide gas and solid snow.

[16] Operate valve. Direct at base of flame with sweeping motion.

[17] Very little expellant pressure available at subzero temperature unless special winterization offered.

[18] Asphyxiation of operator possible in confined spaces. Limited range.

[19] Use only manufacturer recommended refill.

[20] Operate valve. Direct stream downward at base of flame.

[21] If CO_2 cartridge is used very little expellant pressure will be available at sub zero temperatures.

[22] Solution of alkali-metal and other salts.

[23] An apparent physical reaction.

[24] Direct stream at base of flame above surface if burning liquid.

[25] Physical reaction appears to occur and produce extinguishing effect on Class B fires.

[26] Solution of calcium chloride, or potassium carbonate and other salts.

[27] Stored pressure or gas cartridge or gas from acid-salt reaction.

Figure 6. Fire Extinguisher Characteristics

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ELECTRICAL HAZARDS AND SAFETY PRACTICES

Almost everyone is required to work on or around electrical circuits as they do their job in the Air Force. You cannot see electricity; therefore, you cannot determine by looking at a conductor if it is energized by voltage. Also, you cannot determine the amount of voltage applied to the conductor. In order to work safely around electrical equipment, you must understand the following:

- Operation principles of a.c. and d.c. electricity.
- Functions of the electrical circuits you maintain.
- Use of electrical safety equipment.
- Safety precautions to be observed.
- Conditions which cause an electrical shock.
- Effects of an electric shock.

A number of people are electrocuted each year because they fail to understand one or more of the above items. For example, when a person is electrocuted, death resulted from which of the following?

- Voltage
- Current
- Resistance

An electrical shock includes all three of these factors. However, "current" is the "killer" in the case of electrical shock.

Voltage is an electrical pressure which causes tiny electrically charged particles to flow through a conductive material.

Current is the movement of these tiny electrically charged particles (electrons) through the conductive material. Movement of electrons through the human body affect the muscles and nerve system. When the current exceeds a certain value, the muscles affected become paralyzed. This causes the heart to stop beating and the lungs to stop functioning. If this condition prevails long enough, death results.

Resistance is the factor which opposes the flow of current. The amount of resistance that the human body has depends on certain conditions. The skin, when dry, has a high resistance. This skin characteristic acts to protect a person from electrical shock by low voltages. However, when the skin is wet or damp, it has a smaller amount of resistance. Therefore; a person whose skin is wet may be electrocuted by low voltage (about 100 volts), while a person with dry skin may not be electrocuted with voltages of this low value.

Effects of Electric Shock

Electric shock may cause instant death or unconsciousness, cessation of breathing, and burns of all degrees. If a 60 cycle alternating current is passed through a person from hand to hand, or from hand to foot, the effects when current is gradually increased from zero are as follows:

- At about 1 milliampere (0.001 ampere) a slight shock can be felt.
- At about 10 milliampere (0.010 ampere) the shock is severe enough to paralyze muscles so that a person may be unable to release the conductor.
- At about 100 milliampere (0.100 ampere) the shock is fatal if it lasts for one second or more.

Almost all electrical injuries are caused by carelessness or overconfidence in handling equipment. Most personnel are likely to think in terms of high voltages, but death lies in the low voltages too. The following facts are presented to illustrate the hazards of low voltage.

The human skin, through its resistance, acts as a protector against electrical shock. This resistance to electrical current varies between 100,000 and 600,000 ohms for dry skin. It may be as low as 1000 ohms for wet skin. The resistance of the internal body, hand to foot, is about 400 to 600 ohms, and from ear to ear, 100 ohms.

Assume that 120 volts is applied to the perspiring skin of a worker who is standing on a good electrical ground. Further assuming the worker has a total resistance of 1500 ohms, the current through him would be about 0.08 ampere or 80 milliamperes. This amount of current is not always fatal, but it is painful. It causes severe muscular contractions and makes breathing difficult. If the current absorbed is between 100 and 200 milliamperes, it produces a heart condition, wherein the heart muscle fibers work independently and without rhythm, causing instant death.

Electrical Maintenance

Here is the possibility of injury to personnel, the danger of fire, and possible damage to material. Therefore, all repair and maintenance work on electrical equipment should be performed only by duly authorized and assigned persons.

When any electrical equipment is to be overhauled or repaired, the main supply switches should be shut off. This includes switches ih each circuit from which power could possibly be fed. The covers of fuse boxes and junction boxes should be kept securely closed except when work is being done. Safety devices such as interlocks, overload relays, and fuses should never be disconnected except for replacements. Safety or protective devices should never be changed or modified in any way without specific authorization. Fuses should be removed and replaced only after the circuit has been de-energized. When a fuse blows, it should be replaced only with a fuse of the same current and voltage ratings. When possible, the circuit should be carefully checked before making the replacement; since the burned out fuse is often the result of a circuit fault.

If practicable, repair work on energized circuits should NOT be undertaken. When repairs on operating equipment must be made in order to make proper adjustments, every known safety precaution should be carefully observed. Proper lighting should be provided, and the worker should be insulated from ground with some suitable non-conducting material. A helper should be stationed near the main switch or the circuit breaker so that the equipment can be de-energized immediately in case of emergency. A man qualified in first aid for electric shock should stand by during the entire period of the repair. During this type work on energized circuits, safety equipment in the form of gloves, blankets, covers, safety tools, etc., must be used.

Personnel should never work alone near high-voltage equipment. Even very high body resistance and resistance offered by protective clothing and equipment can be offset by high voltages. Tools and equipment containing metal parts should not be used in close proximity to high-voltage circuits or equipment. Handles of all metal tools, such as pliers, should be covered with rubber insulation. Warning signs and suitable guards should be provided to prevent personnel from coming into accidental contact with high voltages.

Work on electrical equipment should not be accomplished with wet hands or while wearing wet clothing since this would greatly reduce body resistance. Wearing thin soled shoes with metal plates or hobnails is unwise. Safety shoes with nonconducting soles should be worn if available. Flammable articles, such as celluloid cap visors, and loose or flapping clothing, should not be worn. Also before working on electronic or electrical apparatus, all rings, wrist watches, bracelets and similar metal items should be removed. Care should be taken that the clothing does not contain exposed zippers, metal buttons, or any type of metal fasteners.

Most portable tools are equipped with a ground wire and a standard ground plug. This will protect the operator in event of a short circuit within the equipment. The ground wire must be connected to an approved ground and should have a total resistance of less than one ohm. Extreme care must be exercised to see that the ground connection is made correctly. If the equipment casing grounding conductor is connected by mistake to a line contact of the plug a dangerous potential will be placed on the equipment casing. This might easily result in a fatal shock to the operator.

Before a worker touches a capacitor which is connected to a de-energized circuit, he should short-circuit the terminals to make sure that the capacitor is completely discharged. Grounded shorting prods should be permanently attached to work-benches where electrical or electronic devices are regularly serviced.

In addition to electrical hazards involved when working with batteries, the danger of acid burns is also present. These burns can be prevented by the proper use of eyeshields, rubber gloves, rubber aprons, and rubber boots with non-slip soles. Another battery hazard is the danger of explosion due to the ignition of hydrogen gas given off during the battery charging operation. This is especially true where an accelerated charging method is used. Open flames or smoking should not be permitted in the battery charging room, and the charging rate should be held at a point that will prevent rapid liberation of hydrogen gas. Manufacturer's recommendations as to the charging rates for various size batteries should be closely followed; also, an adequate shop exhaust system should be used.

Electrical Fires

General cleanliness of the work area and of electronic apparatus is essential for the prevention of electrical fires. Oil, grease, and carbon dust can be ignited by electrical arcing. Therefore, electrical and electronic equipment should be kept absolutely clean and free of all such deposits.

For combating electrical fires, a CO_2 (carbon dioxide) type fire extinguisher is recommended. Water or foam-type extinguishers should not be used since the water or foam will conduct electricity. In cases of cable fires in which the inner layers of insulation or insulation covered by armor are burning, the only positive method of preventing the fire from running the length of the cable is to cut (with insulated equipment) the cable and separate the two ends. When cutting cables it is vital to insure that all electrical power has been disconnected.

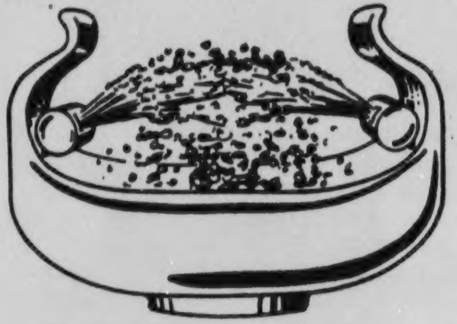

Figure 7. Eye Wash Fountain

SAFETY EQUIPMENT

Various types of safety equipment are provided by the Air Force. You should become familiar with the location and use of the equipment in the following topics:

- Safety Showers
- Personnel Protective Clothing and Equipment

Safety Showers

If a toxic liquid or vapor comes in contact with the skin or eyes, it should be washed off immediately with large amounts of water. Special safety facilities are provided at strategic locations. When newly assigned to a section, you should learn the location of this safety equipment as quickly as possible.

Eye Wash Fountain. When a toxic chemical comes in contact with the eyes, face or hands, the affected areas can be washed quickly by use of the Eye Wash Fountain, Figure 7. This fountain is specially constructed to spray water into both eyes at the same time.

Emergency Shower. In the missile site, a toxic chemical may come in contact with an individual's body. If this should happen to you, remove contaminated clothing and quickly move to the closest Emergency Shower, Figure 8. Enter the shower, turn on the water and thoroughly wash all areas of the body. Be sure to use plenty of soap to assure maximum removal of the toxic agent. Where protective clothing is worn and is exposed to a toxic chemical, wash this clothing off in the shower before you remove it.

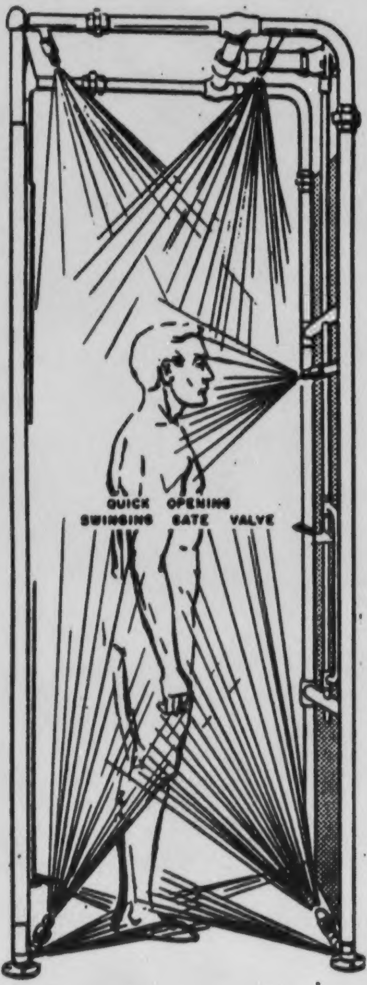

Figure 8. Emergency Shower

Personnel Protective Clothing and Equipment

There are many items of protective clothing and equipment developed for your protection. The complexity of this equipment ranges from simple items such as gloves, eye shield, hard hats, etc., to more complicated items including respirators, self-contained breathing apparatus, and complete protective clothing ensembles. Information on some items of this equipment is given in the following paragraphs. This information is only introductory and at your duty assignment you should determine the type of protective clothing available and make certain you learn its purpose and how to use it. Your general health, and in fact, your very life, may depend on your knowing how to use the equipment available. Four very important aspects of behavior are essential when working in a hazardous area, or with hazardous equipment. These are:

- Be able to recognize the hazard present.
- Understand what the hazard means to you.
- Know what safety equipment is available.
- Know how to use the available equipment.

Ear Plugs. This is about as simple a safety device as you will ever see; however, don't let its simplicity detract from its value. Expect to use these without fail when working in an area where the noise level is continuously high, such as a diesel powerhouse. It is important to realize that sound of moderate intensity, encountered for prolonged periods, can be as injurious to your hearing as high intensity sound encountered for a short period of time. The very best thing to do with ear plugs is to keep them clean and use them. In some cases ear muffs are provided as extra protection for the ears.

Gloves. Gloves are required for protection in many types of jobs. Locate the safety gloves in your area and use them. For the most effective use, you must know which type of glove to use in each instance, and you also must know the proper care of these items. Various types are supplied for electrical work, handling extremely code or hot items, handling various chemicals, and for general physical protection of your hands from bruising, cuts, scratches, etc.

Eye and Face Protective Devices. If any one item of safety equipment could be described as the most important, it would probably be the eye protective equipment. It only takes a very minute piece of foreign material to permanently damage your eye and cause you to lose your sight. To protect your eyes, determine the protective glasses, goggles, or shields required for each particular job or area, and wear this equipment. In case your supervisor cannot inform you of the applicable safety equipment, refer to AFR 127-101, Ground Accident Prevention Handbook. This manual has a wealth of information regarding the protective equipment and the safety procedures for doing various type jobs. Frequent use of AFR 127-101 will increase your chances of staying in good physical condition.

Use of Safety Hats

Hard hats or skull guards are designed to protect your head from falling or flying objects. Most safety hats are water resistant, non-conductors of electricity, and will resist fire. They are available in a variety of styles. Figure 9 shows several types of Air Force approved safety hats.

Since the hat is designed to protect your head, the one offering the most head protection is the one with a full brim. Once you receive your hat, take the time to adjust it properly. Proper adjustment provides for at least 1-1/4 inch of space between the top of your head and the inside crown of the hat. This space is to provide a cushioning effect in event something strikes the hat. Some important items to consider in the use of safety hats are given below.

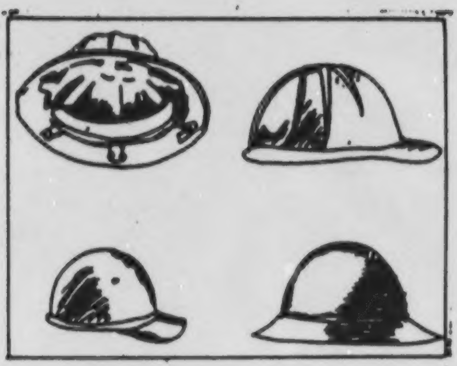

Figure 9. Types of Safety Hats

- Never wear a metal type hard hat around electrical hazards. This is only common sense, since metal is a conductor of electricity.
- Never drill air holes in your hard hat. If it does not already have air holes, do without them as any you drill may cause the material to crack badly.
- The most important thing about safety hats is to be sure and wear them in the designated areas. It is absolutely worthless if you don't wear it.

SUMMARY

The Air Force maintains a ground safety program designed to prevent accidents, and don't ever forget that most accidents can be prevented. Your part in this ground safety program is to become familiar with the causes of accidents and to follow the prescribed rules and precautions to prevent them. Some of the conditions which breed accidents are poor housekeeping, horseplay, improper use of tools and equipment, nonobservance of warning signs, and lack of an adequate fire prevention program. Of course, there are many other causes, among these are cases of personnel working with unfamiliar equipment or material. Therefore, to prevent accidents, it is necessary to know as much as you possibly can about the equipment and materials you come into contact with. In your assignment at various Air Force installations you will be working with, or near, such items as mechanical equipment, electrical equipment, liquid and compressed gases, acids, and possibly even radioactive materials. Take the necessary time to personally learn as much as you possibly can about the equipment around you. Air Force manuals, pamphlets, technical orders, and commercial texts are available from which to learn this material.

When it comes to the maintenance of electrical equipment, this type work should only be performed by those personnel who are fully qualified. The person who maintains electrical equipment must be thoroughly familiar with the circuits and must be safety conscious at all times. He should work on an energized circuit only when it is absolutely necessary; he must use the proper safety equipment and take the necessary precautions to assure complete protection against electrical shock. Remember, electricity always conforms to certain laws of physics. You must treat it with the proper respect; otherwise, your experience in this field may suddenly be terminated.

The Air Force provides a variety of safety equipment and protective clothing, but you must become familiar with its location and use.

QUESTIONS

1. What is the definition of the word "Accident?"

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2. What percentages of accidents are considered by the Air Force as being "Natural Phenomena?"
3. What are five rules of good housekeeping?
4. What type of clothing should not be worn around operating mechanical equipment?
5. What type of wrench is first choice when it is at all possible to use it?
6. What is the ratio of hammer accidents as compared to hand tool accidents?
7. How much cushion space should be maintained between the top of your head and the inside crown of your safety hat?
8. What are the three classifications of fires and what determines each class?
9. What type fire extinguisher must always be used on electrical fires?
10. What is considered to be the minimum electrical voltage which will cause death by electrocution?
11. What is the first precaution to observe if you are required to work on an energized electrical circuit?
12. What factor is the "killer" in electrical shock?
13. Can 100 volts be fatal to the average person?
14. What is the amount of current and the time of application to produce a fatal electrical shock?
15. What is defined as contact resistance?
16. What are the hazards to be considered when working on or around lead acid batteries?
17. What is the purpose of grounding electrical equipment?
18. Name at least four items of protective clothing or safety equipment.

REFERENCES

AFR 127-101, Ground Accident Prevention Handbook

AFP 85-1, Electrical Facilities Safe Practices Handbook

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SECTION II

NUCLEAR SAFETY

You must be familiar with the Nuclear Safety Program, adhere to safety rules, employ safe practices, and report or correct unsafe conditions. A nuclear accident is one which we cannot afford. You must know about nuclear safety and you must follow all the prescribed nuclear safety rules if your duty is with or near a nuclear device.

Information on nuclear safety will be presented in the following topics:

- THE AIR FORCE NUCLEAR SAFETY PROGRAM
- THE TWO-MAN CONCEPT
- SAFING AND SEALING

THE AIR FORCE NUCLEAR SAFETY PROGRAM

The nuclear safety program guards our combat readiness by preventing nuclear accidents, incidents, and deficiencies.

The Air Force achieves safety in nuclear systems by:

- incorporating safety design in the system.
- adhering to safety rules and technical specifications and procedures governing system operation.
- employing safe practices during system use.
- correcting unsafe conditions as they develop.

For the nuclear safety program to continue to be successful, individual nuclear weapon system team members must:

- study and know nuclear safety rules and standards.
- observe and employ nuclear safety rules and standards.
- report and correct unsafe conditions or procedures.

THE TWO-MAN CONCEPT

The TWO-MAN CONCEPT is designed to prevent the accidental or unauthorized firing of a nuclear weapon. AFR 122-4 establishes the TWO-MAN CONCEPT which is mandatory for nuclear weapons or nuclear weapon systems.

Certain areas at a weapon system site are designated as a NO-LONE ZONE. A NO-LONE ZONE is an area:

1. That contains one or more critical nuclear weapon components to which a lone individual must be denied access.
2. From which one person could fire a nuclear weapon.

During all activities in a NO-LONE ZONE, the TWO-MAN CONCEPT must be rigidly enforced.

Individual two-man team members must:

1. Be capable of detecting an incorrect procedure or unauthorized act on the part of the other member regarding the task being performed.
2. Be familiar with applicable safety and security requirements.
3. Be authorized by competent authority.
4. Upon detection of an incorrect procedure or unauthorized act:
    a. Take positive steps to terminate the task or act, and
    b. Immediately notify proper authorities of the deviation.

The TWO-MAN CONCEPT is a very important aspect of nuclear safety. Safing and sealing are another very important part of nuclear safety.

SAFING AND SEALING

AFR 122-5, Safing and Sealing, applies to each major command with an operational nuclear weapon responsibility. These commands must develop appropriate procedural directives to meet safing and sealing requirements of Nuclear Weapon System Safety Rules.

Explanation of Terms

Safing. The method used to protect a nuclear weapon/weapon system switch, cover, handle, and/or other critical components from inadvertent activation or entry.

Sealing. The method used to provide evidence of activation or of tampering with a nuclear weapon/weapon system switch, cover, handle, and/or other critical component.

Seal. A device used in sealing, which by its unique design and/or marking, minimizes the possibility of counterfeiting, substituting, removing, or reinstalling that device without detection.

Crimping Device and Die. Specifically designed equipment for installing a seal which will cause that seal to bear a distinctive or unique marking after proper installation.

Responsibilities and Procedures

Each major air command with an operational nuclear weapon responsibility will develop and issue appropriate procedural directives governing safing and sealing. As a minimum, these directives will:

1. Require the designation of individuals authorized to apply/remove seals.
2. Provide guidances as to when seals are to be applied or removed.

3. Require the establishment of controls for receipt, storage, issue, inventory, and disposal of distinctive seals, and/or crimping devices/dies.

4. Require the periodic inspection of seals on nuclear-armed aircraft, missiles, and associated control systems.

5. Prescribe action to be taken when a seal is found broken or displays evidence of tampering.

SUMMARY

The Nuclear Safety Program guards our combat readiness by preventing nuclear accidents, incidents, and deficiencies.

USAF Headquarters is responsible for the program and provides staff supervision over all matter pertaining to the program.

The Air Force Systems Command and Logistics Command share in the responsibility for nuclear weapons system safety. This includes nuclear safety in the design, development, and operation of a nuclear weapon system.

The Two-Man Concept and safing and sealing requirements provide for nuclear safety by preventing the unauthorized arming, firing, detonating, or releasing of a nuclear weapon or the launching of a nuclear weapon delivery system.

QUESTIONS

1. What is the purpose of the Nuclear Safety Program?
2. What organization is responsible for this program?
3. Name four ways by which the Air Force achieves safety in nuclear systems.
4. How can individual nuclear weapon system team members contribute to the Nuclear Safety Program?
5. What is the purpose of the Two-Man Concept?
6. What is a No-Lone Zone?
7. In the Two-Man Concept , what is the responsibility of individual team members?
8. Define the term "safing."
9. Define the term "sealing."
10. Who prescribes the action to be taken when a broken seal is found on an operational nuclear weapon?

REFERENCES

1. AFR 122-1, The Air Force Nuclear Safety Program.
2. AFR 122-4, The Two-Man Concept
3. AFR 122-5, Safing and Sealing

SECTION III

RADIATION SAFETY

With the increased use of atomic energy, the possibility of coming into contact with nuclear radiation is increased. For this reason it is important to know the types of radiation, the effects of exposure to radiation, and the safeguards to be taken when working in areas containing radiation sources.

Radiation safety is an important thing in your life today and supplementary reading of additional material is highly recommended. AFP 136-1-3 contains an excellent coverage of hazards involved, the maximum safe exposure rates, and additional precautions to observe. Once you are exposed, it is a little late to start reading up on the subject and you never know when you may be exposed.

Information on this subject will be covered in the following topics:

- IMPORTANCE OF RADIATION SAFETY
- RADIATION PROTECTION

IMPORTANCE OF RADIATION SAFETY

Nuclear radiation can cause a variety of personnel injuries from loss of hair from a minor dosage, to rapid emaciation and death from lethal dosages. Personnel should wear radiation exposure indicators at all times while on duty since radiation becomes dangerous when the body is over-exposed to a source of highly concentrated radioactive material. Since radioactive rays cannot be detected by any of the five senses (sight, sound, smell, taste, or feel), a victim can have an overdose without any apparent knowledge. A strong overdose causes vomiting to occur several hours after exposure.

It is important to realize that you can become exposed to radiation without the explosion of a nuclear bomb. Radiation sources are found in many places. X-ray equipment and radioisotope therapy units in hospitals are possible sources for exposure. Also stock rooms where electronic tubes, radioactive decals, luminous markers, and other radioactive materials are stored, are radiation hazards.

The explosion of a nuclear bomb, like that of an ordinary bomb, but many thousands of times more powerful, causes damage by blast or shock. The nuclear explosion also presents other important dangers in addition to blast shock. These changes are generally referred to as thermal radiation and nuclear radiation (initial and residual). As an airman, you do not need to become an expert on the nuclear bomb. However, there are certain facts that you must understand to protect yourself from this weapon and its radiological effects.

Nature of Nuclear Explosions

The four characteristics of a nuclear explosion are: blast, thermal radiation, initial nuclear radiation, and residual nuclear radiation. The effects of blast, thermal radiation, and initial radiation cover a large area and occur almost instantaneously with the explosion (see Figure 10). Your protection from these dangers will depend upon your distance from the detonation point and the type of shelter or shielding you use.

The last of these characteristics - residual nuclear radiation - is given off by the fallout after the explosion. This is shown in Figure 11. The term "fallout" is used to describe the radioactive dust or particles produced by the explosion of a nuclear bomb. This radioactive dust falls back to earth from the upper air after the explosion is over. If you are exposed to a heavy concentration of fallout, you may become ill or even die. You can avoid overexposure from fallout of radioactive dust if you know how and what to do in case of a nuclear explosion. Your disaster control personnel will determine the probable areas of fallout and what protection should be taken. Remember, you cannot see or feel residual nuclear radiation. Therefore, it is important that you know how to protect yourself against this hazard.

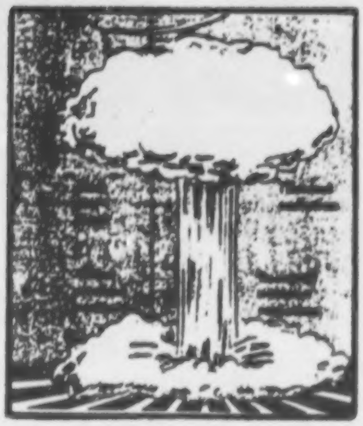

Figure 10. Nuclear Explosion

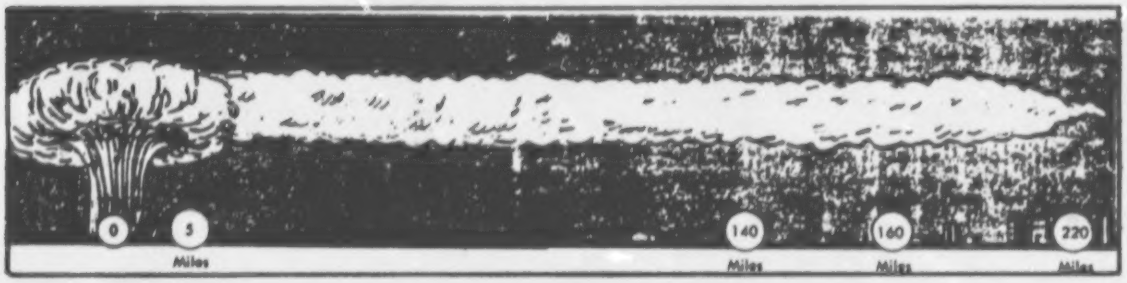

Figure 11. Fallout

Effects of Nuclear Explosions

To begin with, you must realize that the nuclear bomb is just another way of causing an explosion. The destructive effects of blast or shock in a nuclear explosion are similar to those of an ordinary high-explosive bomb; however, nuclear explosion damage is due to the violent change above and below normal atmospheric pressure. There is a great wave of increased pressure outward on objects, followed by a returning wave inward with decreased pressure. This is shown in Figure 12. These two waves of pressure cause the greatest destructive damage because of the difference in air pressure acting on separate surfaces of a structure. Your greatest danger from blast will be falling objects or flying debris. Nearly half the total energy of a nuclear explosion is in the form of blast.

At the instant of a nuclear explosion, an extremely hot and shining mass, called the "fire ball," is formed. Immediately after the ball of fire is formed, it starts to emit thermal radiation. The thermal radiation consists of ultraviolet, visible, and infrared rays. These rays will cause severe skin burns of various degrees to exposed personnel several miles away from the point of explosion. Thermal radiation is also capable of starting fires at considerable distances from the point of explosion. Thermal rays move outward from the nuclear explosion's ball of fire with the speed of light and are

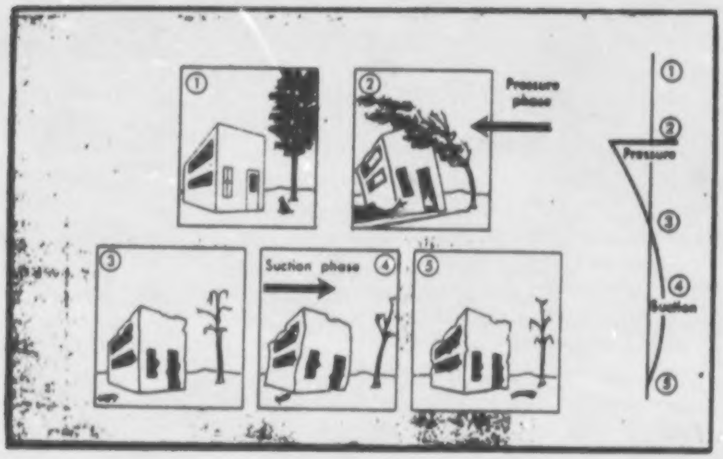

Figure 12. Effects of Blast and Shock Wave

delivered at great distances in a fraction of a second. Therefore, it is important that you protect yourself from thermal radiation immediately upon the indication of a nuclear explosion.

The explosion of a nuclear bomb is associated with emission of nuclear radiation. Initial nuclear radiation is generally defined as the nuclear radiation emitted within the first minute after explosion. Initial nuclear radiation is composed of highly penetrating and harmful, but invisible, neutrons and gamma rays.

Neutrons are emitted in the initial weapon burst and have an effective range comparable with gamma rays. They are harmful to the human by direct radiation and indirectly by producing radioisotopes which appear in the fallout material.

Finally, you have to contend with residual radiation remaining after the nuclear explosion is over. As stated previously, the contaminated particles and debris which fall back to earth after the explosion is over are referred to as fallout. Fallout is the main source of residual nuclear radiation and is very dangerous since it remains radioactive for a long period of time and spreads to great distances from the explosion. Residual radiation is of major importance to you because it is composed of highly penetrating and harmful gamma rays as well as harmful beta particles.

Types of Injury Caused

It is possible for personnel to be injured in three ways by explosion of a nuclear bomb: blast injuries, thermal radiation injuries, and nuclear radiation injuries.

Blast Injuries. These are largely indirect injuries caused by falling buildings, flying debris, or by being hurled against a solid object.

Thermal Radiation Injuries. These are burning injuries caused by thermal radiation from the fire ball, or secondary fires.

Nuclear Radiation Injuries. This is in the form of radiation sickness caused by overexposure to initial nuclear radiation, or more often residual nuclear radiation.

Residual Nuclear Radiation

There is one important fact about residual nuclear radiation that you are likely to overlook. That is, while heavy fallout (residual radiation) is a new factor, radiation itself is not something new and is not found only in nuclear explosions. You have been bombarded by radiation every hour of your life by cosmic rays from outer space. You also receive a certain amount of exposure when you have a chest X-ray. This is done by sending invisible (but powerful) rays through some part of your body. For example, when X-rays are taken of your hand you feel nothing. However, the X-rays have penetrated your hand. The light shaded outline of your bones on the film means that some X-rays have been stopped or absorbed by the bones. Too many X-rays will tend to tear down body cells, especially the blood-forming cells, thus causing injury. That is why a safety limit is set up. X-ray machine operators are allowed to be exposed only to a certain amount of radiation each week. You have also heard of doctors using radium in the treatment of cancer. In receiving this treatment, the patient is exposed to powerful penetrating rays. The objective is to use the rays to kill the cells that form the nucleus of the cancer formation. The doctor has to control the number of treatments he gives to a patient or treatment would be fatal. In other words, the radiological hazard and effects caused by radiation are not unknown to you. Now that you know something about it you can do something about protecting yourself from radiation effects.

The greatest danger from residual radiation comes from exposing yourself for long periods of time to radioactive particles. These particles may be near you or may fall with dust, settling on your body or clothing. Fallout, like X-rays, can destroy living tissue, particularly in the blood forming system. Therefore, airmen working in a radioactive or "hot" area will not be allowed to absorb residual radiation beyond a safe limit as determined by your disaster control officer and medical officer. While you can become seriously ill, and even die, from breathing radioactive dust, there is less danger than when your whole body is exposed to nuclear radiation either residual or initial. Remember: All types of radiation are dangerous (residual, initial, thermal, X-ray, radium, or even an infrared lamp) because you cannot hear, see, taste, smell, or feel radiation rays.

The three important types of residual radiation are alpha particles and beta particles, and gamma rays, see Figure 13. Any agent or material that gives off alpha, beta, or gamma is said to be radioactive.

Alpha particles can be stopped by a sheet of paper and are dangerous only when inside the body. Beta particles have little penetrating ability, but may inflict severe burns. The gamma ray differs from alpha and beta particles in that it has high penetrating ability. Thus, a body exposed to gamma rays receives radiation both inside and out, frequently resulting in serious radiation sickness. Many people believe that very little can be done in treatment of radiation sickness. This is true in case of a lethal dose, but certainly is not true when the exposure is in the median lethal range. Many borderline cases can be saved by good medical and nursing care; whole blood transfusions; control of infection by antibiotics; intravenous feeding to supply necessary sugars, proteins, and vitamins; and control of the bleeding tendency by use of drugs.

There are certain measures set up by your disaster control officer to protect you from receiving extremely large doses of radiation. Your disaster control personnel will indoctrinate you on the procedures to use while in a contaminated area. Be sure you follow their instructions.

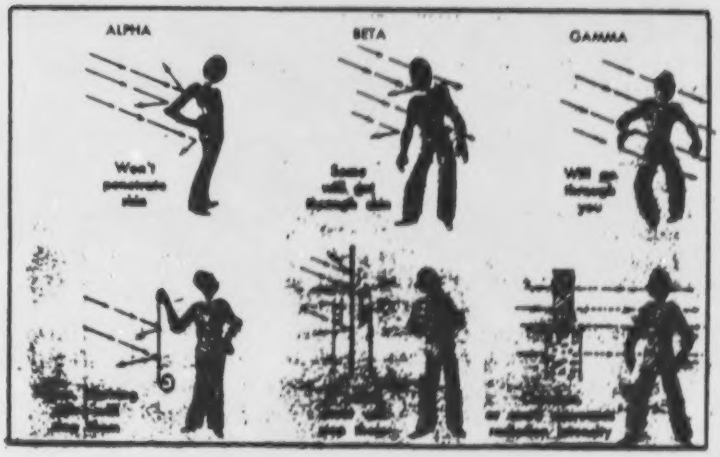

Figure 13. Residual Radiation

To obtain a better understanding as to why residual radiation is so dangerous you must know a few facts about residual radioactivity. When dealing with residual radiation you will be concerned primarily with beta particles and gamma rays. The beta particle cannot travel as far as the gamma ray, refer to Figure 14.

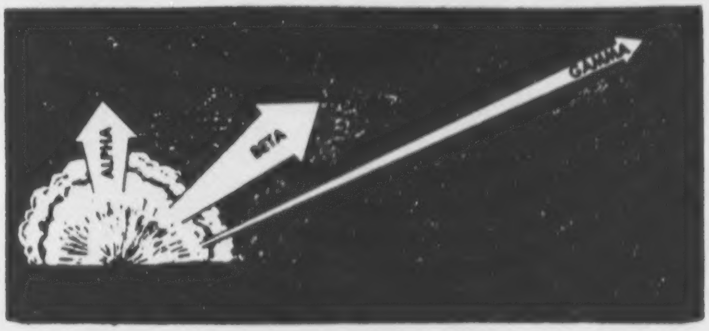

Figure 14. Distance of Travel Through the Air

Also, beta particles cannot penetrate any great thickness of material. Most beta particles can be stopped by moderate clothing. While beta particles may be less penetrating than the gamma ray, they represent a potential hazard. When beta particles accumulate on your bare skin, you can receive a beta burn and become a casualty.

The gamma rays travel great distances through the air and can penetrate considerable thicknesses of material. It is because these rays can neither be seen nor felt by human beings (but can have harmful effects at great distances from their source) that they are important in nuclear explosion. The gamma rays can pass through concrete or earth just as radio waves can penetrate the walls of buildings to make your radio operate. Of course, gamma rays are weakened by passing through concrete, but some of them will get through. How much gets through depends upon the thickness of the concrete.

The first indication of an overdose of residual radiation probably will not show up for several hours or possibly days. Then you most likely will get sick and begin to vomit. The time elapsing prior to your illness depends on how large a dose you have received. It does not mean that when you start vomiting you are going to die. For a few days you might continue to feel far below par, but with proper medical care you would still stand a better than even chance of complete recovery.

RADIATION PROTECTION

The effects of blast, thermal radiation, and nuclear radiation will vary with the location of the point of burst in relation to the surface of the earth. Therefore, in order to be able to protect yourself against nuclear explosions, you must have an understanding of the different types of bursts. The main types to be considered are air burst, surface burst, and subsurface burst.

Self Protection

Let us now consider the defensive action to take in case of a nuclear explosion. In planning such protection there are several variables to consider, such as type of burst, distance from explosion, weather conditions, and shelter available. What defensive action may be taken then for the different types of bursts?

The type of cover you would take in case of an air burst will depend upon your mission, location, whether or not you are warned, and many unforeseen factors. As with any explosion, the more protective material, or distance between you and the burst, the safer you are. It is doubtful that you will be warned far enough in advance so that you can reach a safe distance from the explosion. Therefore, if you are caught in the open, you should drop immediately to a prone position (see Figure 15). If you are inside a building, fall to the prone position and crawl under a desk or any item that will offer protection from flying debris. Falling flat on the ground and covering your face is better than standing. Above all, do not attempt to get up until you are sure that the blast effect has passed over.

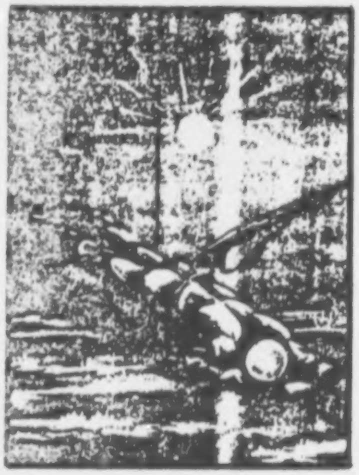

Figure 15. Elementary Protection

As previously noted, a concrete shelter is better than wood and an underground shelter is better than a fox hole; although any of these is better than standing out in the open. As is true with protection from all dangers of war, you as an airman must make the most of what you have. Remember that speed in taking cover is vital, and if you are able to protect yourself against the effects of blast and thermal radiation, you will generally be well protected from the initial radiation.

In the event of a surface or subsurface burst by a nuclear explosion, the area contaminated by fallout will extend well beyond the range of blast and thermal radiation. Further, the effects of blast and thermal radiation are over in a few seconds while residual radiation remains for considerable time. The protection taken against sources of residual nuclear radiation may be either passive or active. Passive protection means

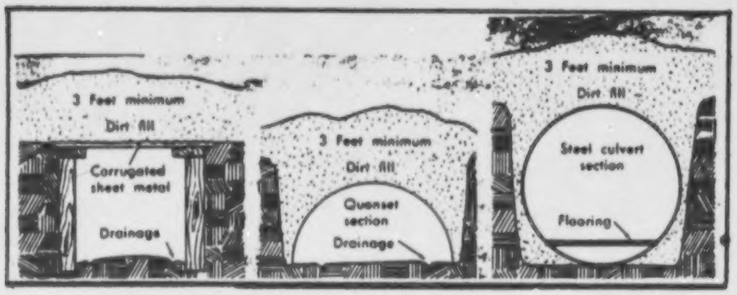

Figure 16. Types of Simple Earth Shelters

to remain in the contaminated area while taking all possible shelter from the gamma rays. This could be underground shelters, basements, or fox holes covered with several feet of earth, see Figure 16.

Since you have no way of knowing whether your shelter is safe from residual radiation, your disaster control personnel will check to find out. From their check it will be determined how safe your shelter area is and if it is safe to remain there.

Active protection is evacuation from the contaminated area to one that is free from contamination or to one which is less contaminated. This action is by no means easy since the resulting radiation exposure may be greater than if passive protection measures were taken. Therefore, it is impossible to make any definite recommendations. The action taken will depend upon your disaster control personnel; always rely upon their knowledge and judgment. Above all, remember that your mission may require you to remain in the area. You may have to leave your shelter to help in decontaminating the area. But your disaster control personnel will continue to keep check on the amount of exposure you have received regardless of what you are doing. One of their main concerns is your safety.

In general, the protection against nuclear explosions (regardless of the type of burst) may be summed up by the terms "distance" and "shielding." In other words, it will be necessary that you get beyond the reach of the effects or get as much material as possible between you and the source of radiation. Since it is very doubtful that you will have time, or that your mission will allow you, to get beyond the effects of a nuclear explosion, you must be prepared to put a sufficient mass of material between you and the explosion. This means that you will have to use what is at hand. To act safely, you must remember what forces you are facing (blast, thermal, and nuclear radiation) and put up the best possible defense against them.

Protective Equipment

All personnel entering a contaminated area should wear protective clothing to prevent the entry of radioactive dust. The main reason for this precaution is to shield beta particles from your skin. Beta particles won't penetrate far into your body but they will damage the skin. The effect is a reddening and blistering of the skin and is called "beta burns." Such damage may not appear until some time after exposure since beta particles have a delayed action. You may not know you have received skin burns from beta particles until it is too late to prevent painful injuries. In the event you feel you have been exposed, let the medical people examine you. They are better qualified. Always play safe by wearing any protective clothing you have in the manner in which you are instructed to wear it. Also you should remember that clothing offers very little protection against gamma rays. Therefore, in addition to taking steps to prevent beta particles from reaching the skin, you should have your self-indicating meter with you.

When you enter a "hot" area, keep radioactive dust off your body and out of your system. If you inhale radioactive dust into your system, you can obtain a serious internal injury. If there is radioactive dust in "hot" areas, be sure that you wear your protective mask. Your disaster control personnel will inform you about the condition of the area you are entering; therefore, be sure to follow their instructions. Above all, you must remember to wear gloves to protect your hands while in a contaminated area. Touching radioactive material with bare hands will result in serious injury. By wearing gloves it will be easier to decontaminate your hands, especially under the fingernails. You cannot afford to be careless when working in a radioactive area.

Any clothing that covers you gives some protection against beta particles. In order to protect the basic clothes you are wearing from radioactive dust, extra or protective clothing is desirable. For dry operations, heavy clothing and shoes should be worn. You should also wear cotton or canvas work gloves and a tightfitting cap. It is advisable to tie the bottoms of the pantlegs (over the shoes) and the end of the sleeves (over the gloves) to prevent the entry of radioactive dust. If the area you enter has large quantities of dust, you should wear your protective mask or dust respirator to prevent inhaling it. When you are doing wet decontamination, you should wear water-repellent clothing, rubber boots, and rubber gloves. Make certain that your rubber clothing does not have breaks or tears because this would allow beta particles to enter.

Radiation Detection and Measurement

Instruments developed for the detection and measurement of radiations are called radiac, or radiosurvey instruments. Radiac is an abbreviation for radiation detection, indication, and computation. Radiac instruments measure the absorption of radiation, either in terms of dose-rate or dosage.

Dosage is the term applied to the total or accumulated amount of ionizing radiation recieved regardless of the time involved. Dosage is measured in terms of roentgens (r) or milliroentgens (mr). A person could absorb 200-r in a minute, an hour, a week, or a year, and the dosage would be only 200-r. Dosage is accumulative; however, if a person absorbed 20-r the first day, 5-r the second day, and 6-r the third day, the total dosage would be 31-r.

The total quantity of ionization received during a single radiation experience is called a dose. The radiation dose in roentgens is referred to as an exposure dose. It is a measure of the total amount of ionization that a quantity of radiation could produce in air. This is different from the absorbed dose, given in reps or rads, which represents the energy absorbed from the radiation per gram of specified body tissue. When a small portion of the body, say 100 grams of tissue, and the whole body, say 80,000 grams of tissue, are exposed to the same dose-rate of radiation the effects produced will differ. A dose of 5,000 r can be used to treat skin cancer on the hand. This will leave a scar but will not affect the entire body to any great degree. On the other hand, absorption of 500 r by the whole body would be fatal to a majority of those exposed.

In addition to the dose-rate detection instruments used by disaster control personnel, all personnel in your unit may be issued a dosimeter. This is a detection device used to indicate the radiation dosage you have received.

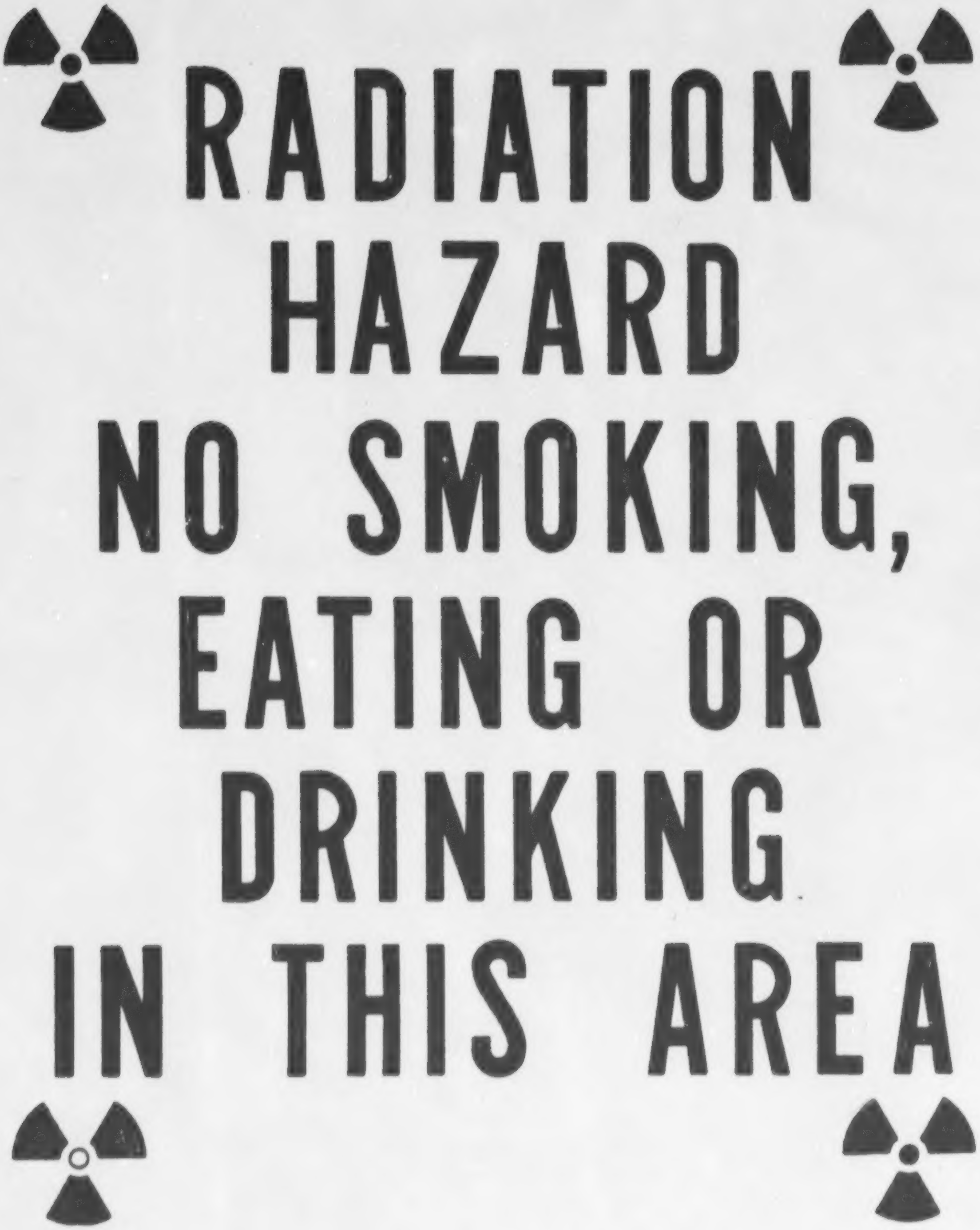
RADIATION
HAZARD
NO SMOKING,
EATING OR
DRINKING
IN THIS AREA

Figure 17. Radiation Indigestion Hazard Placard

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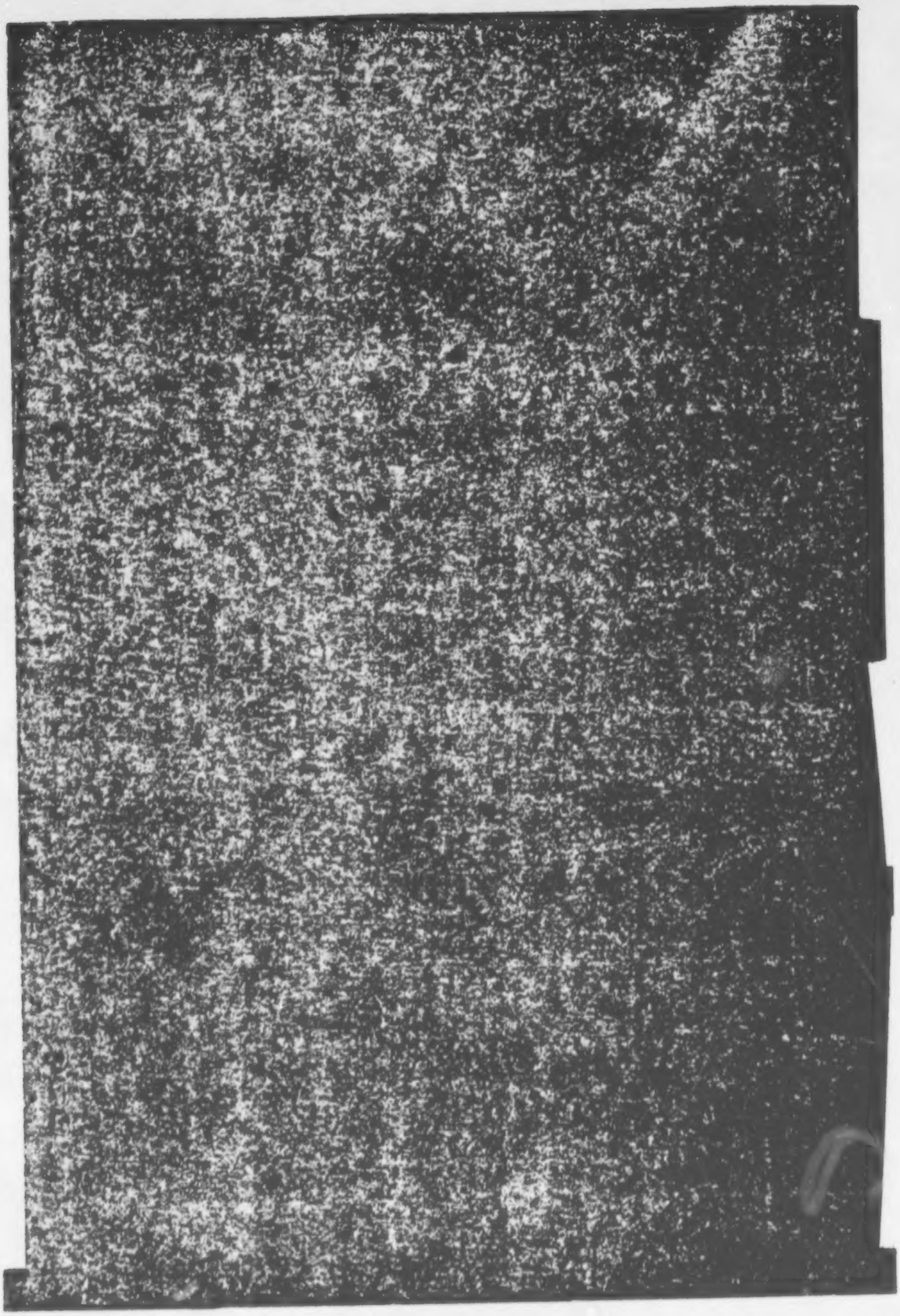

Figure 18. Radiation Area Warning

Warning Signs

AFTO 9 Series of forms are used to aid in the identification of radioactive material.

These have a background of yellow with red symbols and black lettering. Any time these warning signs appear, precautions must be taken against the radiation hazard identified. Such warning placards are illustrated in Figures 17 and 18.

SUMMARY

The primary defense against radiological effects of nuclear detonations is to prevent or minimize nuclear radiation casualties from nuclear bursts, or from radioactive materials used as casualty agents. Radiological effects, whether caused by radioactive agents without a nuclear explosion or by the nuclear bomb, are not mysterious. You have been exposed to various radiations many times. While radioactivity has attracted considerable interest because it represents a new type of attack, casualties due to this hazard are likely to represent a fairly small portion of the total. You must remember that this will depend upon several factors, such as type of shelter or shielding used, ability to decontaminate, type of burst, weather conditions, type of terrain, as well as distance from the detonation point.

Your safety from radioactivity depends upon your ability to identify radioactivity warning signs and signals, and to take the appropriate safeguards against personal contamination. In other words, your safety here is the same as in any other situation. Know what the hazards are, know how to identify the hazards, and know what safety measures to take. Learn as much as you can while you have the time, so that you can take care of yourself when the need arises.

QUESTIONS

1. What publication covers radiation hazards and precautions?
2. What are some of the fairly common sources of radiation?
3. In a nuclear attack, what offers the greatest danger to you?
4. What are four characteristics of a nuclear explosion?
5. How can you detect nuclear radiation:
6. What offers you the greatest protection from radiation?
7. What series of forms are used as radiation warning signs and labels?
8. If you feel you have been exposed to radiation, what is the first thing you should do?
9. If you are required to work in close proximity to radioactive materials, what safeguards should you take?
10. Whose knowledge and judgement should you rely upon when working in a radiation-contaminated, "hot" area?

REFERENCE

TO 00-110A-8, Radiological and Disaster Recovery at Fixed Military Installation

SECTION IV

FIRST AID

Some day you may save someone's life, possibly your own, if you know how to properly render first aid. As you know, first aid refers to the treatment given the sick or injured before regular medical or surgical treatment can be administered by trained personnel.

The fundamentals of first aid are easily learned. You can improve your handling of emergencies just by acquainting yourself with the contents of this section. Information of value to you is presented in the following topics:

- SPECIFIC TYPES OF WOUNDS
- FRACTURES AND SEVERE BURNS
- HEART-LUNG RESUSCITATION
- EMERGENCIES FROM TOXIC SUBSTANCES
- PREVENTION OF ADVERSE EFFECTS OF HEAT

The information presented in the following paragraphs is not intended to qualify you as a doctor or even as a medical aid man, but it may help you save a life.

SPECIFIC TYPES OF WOUNDS

The life saver steps: Stop the bleeding, prevent shock, and protect the wound, should be carried out when treating any person who has suffered injury.

Stop the Bleeding

First apply pressure to the wound with a dressing or any clean article of cloth. The dressing is placed against the wound and firm pressure should be applied as long as needed. If the wound is on an arm or leg, and if bleeding continues, place the patient in a prone position with the injured limb raised. The limbs should not be raised if broken bones are suspected.

If blood is gushing from the wound and the previously discussed methods of stopping the bleeding have failed, a tourniquet should be applied. The tourniquet should be tightened only enough to stop arterial bleeding (gushing of blood from the wound). Always place the tourniquet between the wound and the heart, in most cases just above the wound; however, in case of bleeding below the knee or elbow, a tourniquet should be placed above these joints.

The patient should be seen by a medical officer as soon as possible after the tourniquet is applied. The tourniquet should not be loosened by anyone except trained medical personnel.

Bleeding can often be reduced or stopped by applying hand or finger pressure at various points on a patient's body as indicated in Figure 19.

The pressure points in the groin and neck are particularly important. If the wound is too high on the leg for a tourniquet to be applied, the pressure points in the groin can be used. A neck pressure point should be used when the patient has a profusely bleeding scalp wound. Use the neck pressure point only when other methods of stopping the bleeding have failed. Do not apply pressure to both neck points at the same time or the blood supply to the brain will be critically reduced.

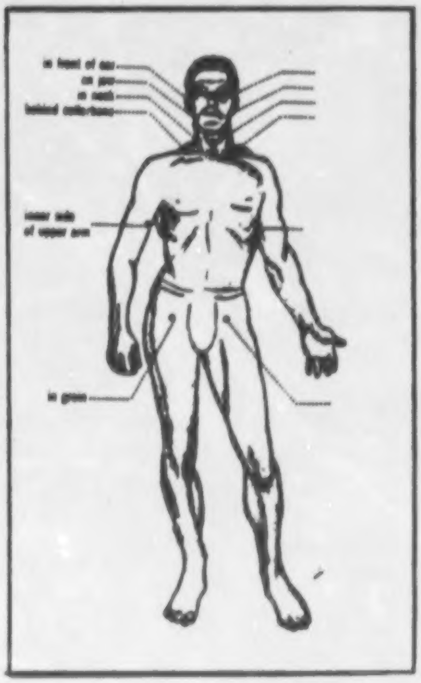

Figure 19. Pressure Points for Bleeding Control

Prevent or Treat Shock

Treatment for shock is started as soon as you come upon a casualty. Shock is a condition of great weakness of the body. It can, and often does, result in death, and may be caused by any type of injury. The more severe the injury, the more likely the occurrence of shock.

A person in shock may tremble and appear nervous. His pulse becomes rapid and weak. He may be excessively thirsty. He may become quite pale and wet with perspiration. He may gasp for air, and he may pass out.

A person may not go into shock for sometime after an injury; therefore, he should be treated for shock whether he has shock symptoms or not. To prevent or treat shock, make the patient comfortable. Remove any bulky items the patient has been carrying. Loosen his belt and clothes. Handle him gently. Do not move him more than is absolutely necessary. If he is lying in an abnormal position, make sure no bones are broken before you attempt to straighten him out. If there is no head wound, lower his head and shoulders, or if possible, raise his legs to increase the flow of blood to the brain. Patients with head wounds are treated as described in the section covering head wounds. Use a blanket, coat, etc., to keep him from becoming chilled. Be sure to put something under him to protect him from the cold ground. If he is unconscious, place him face down with his head turned to one side. This position helps to prevent choking should he vomit. Once you have the patient in the proper position, don't move him because to do so might make his blood pressure drop.

If the patient remains conscious, replace body fluid by giving him coffee, cocoa, or tea to drink. Do not give fluids to a patient who is unconscious or to one with a stomach wound. In some cases it may be advisable to apply breathing oxygen if available.

Protect the Wound

A dressing held in place by a bandage helps protect the wound from germs; foreign matter, and further injury. Keep your hands off the wound and do not touch the side of the dressing that goes next to the wound. Don't pull clothing over the area to be treated; tear or cut clothing away from the wound.

To treat a belly wound, cover it with a sterile dressing from a first aid pack or kit, fasten the dressing securely and treat the patient for shock. Do not try to replace organs such as intestines, protruding from the belly. To do so might cause infection and sever shock. However, if it is necessary to move an exposed intestine in order to cover the wound then do so. Be sure to keep the intestines wet with water. Do not give food or water through the mouth but the person's lips may be moistened with a wet cloth.

Chest wounds are particularly dangerous if air is being sucked in and blown out of the chest cavity through the wound. When such condition exists, the wound itself is not as dangerous as the air which goes through it because the air squeezes the lung, and may cause it to collapse. Make a chest wound airtight as soon as possible. The victim's life may depend on it. To make the wound airtight, have the patient forcibly exhale, if possible. Immediately apply a dressing which is large enough to stop the flow of air through the wound. Pack the dressing firmly over the wound. Cover the dressing with a large piece of material, such as from a waterproof garment to help make the wound airtight. Bind this covering securely with a belt or strips of torn clothing. Encourage the patient to lie on his injured side so that the lung of his uninjured side can receive more air.

Head wounds may consist of one of the following conditions or a combination of these conditions; a cut or bruise of the scalp, fracture of the skull, or an injury to the blood vessels to the scalp, skull and brain. A scalp wound is easily detected because of the profuse bleeding. To treat such a wound, perform the three life saver steps described above. Once dressing is applied, do not remove it.

It is more difficult to discover internal injury to the head. Suspect a brain injury. if an individual:

- Is, or has recently been unconscious.
- Has blood or other fluid escaping from the nose or ears.
- Has a slow pulse.
- Has a severe headache.
- Is vomiting.
- Has had a convulsion.
- Has different sized eye pupils.
- Has difficulty remaining conscious.

In any head injury do not place the patient's head in a position lower than the rest of his body. Keep him flat on his back unless he is unconscious or unless the wound is on the back of his head. If the patient is unconscious, examine the mouth for false teeth or other objects which might cause choking. Place him face down with head turned to one side.

Extreme care must be taken with patient's with head wounds. Obtain expert medical treatment if at all possible. If he is unconscious, move him on a litter face down.

Bleeding from the neck usually is severe because of the many blood vessels in this area. Stop the bleeding by exerting pressure with a sterile dressing. Then bind the dressing so as to protect the wound. If the large artery, or vein is cut, apply hand pressure both above and below the cut. A patient with a penetrating neck wound needs special treatment to prevent him from choking on blood. Have him lean forward with his head held forward and down or have him lie face down. These positions allow the blood to drain out of his mouth instead of into his windpipe. Treat for shock but do not use the face up shock position, AND GET MEDICAL HELP AT ONCE.

Part of the treatment for jaw wounds is similar to that of neck wounds, because usually there is severe bleeding and consequently danger of choking on blood. Have the patient sit up with his head held forward and down. If his jaw is broken, do not bandage his mouth tightly shut. Place the absorbent part of the dressing over the wound and tie the tails over the top of the head to lend support to the jaw. When treating a jaw wound as in the case of a neck wound, do not use a face up - head low shock position.

FRACTURES AND SEVERE BURNS

When treating patients with fractures, remember two important points: prevent shock, and prevent further injury. Careless handling of patients with fractures can result in further injury.

A fracture should be suspected if there is:

- Tenderness over the injury with pain on movement.
- Inability of the victim to move the injured part.
- Unnatural shape.
- Swelling and a change in color of the skin.

A fracture may or may not have all these signs. If you are not certain whether a fracture is present or not, give the patient the benefit of the doubt, treat the injury as a fracture.

There are two types of fractures. A closed fracture (simple fracture) is a break in the bone without a break in the overlying skin. An open fracture (compound fracture) is a broken bone with a break in the overlying skin, with the broken bone protruding.

Most fractures require splinting. Proper splinting relieves pain and helps prevent further injury. The reduction of pain cannot be overemphasized, because excessive pain increases the danger of shock.

Arm Fractures

Fractures of the arm should be supported with splints whenever possible to keep the fractured bone from moving. Temporary splints can be made from such items as boards and branches. The splint should always be padded with soft material to protect the limb from pressure and rubbing. Bind the splints securely at several places above and below the fracture but not so tightly as to stop the flow of blood. Apply a splint to either side of the arm. If an injured elbow is bent, do not try to straighten it; if straight, do not bend it.

A sling is the quickest way to support a fractured bone of the arm or shoulder, a sprained arm, or an arm with some other painful injury. The arm should be bound snugly to the body to prevent movement. You can make the sling by using any material that will support all the portion of the lower part of the arm and hold it close to the body.

Fractured Backs

First Aid for Broken Backs. Often it is impossible to determine whether a person has a broken back or not. Suspect a fracture with any back injury, especially if the back has been sharply struck or bent. Remember, if there is a fracture, and the bone fragments are moved, the spinal cord may be cut. The following first aid procedures should be followed if a person has, or may have, a broken back:

- Place the patient on a flat surface.
- If a patient must be moved, lift him on the litter without bending his spine forward and secure the patient to the litter in several places.
- Carry the patient face down in a blanket litter if he is already in a face down position.
- Keep the patient's body lying straight and natural, with the air passages kept free.
- Treat for shock, but keep the patient flat rather than in a shock position.

The following is a list of things that should not be done:

- Do not move the patient unless absolutely necessary.
- Do not raise his head, even for a drink of water.
- Do not twist his neck or back.
- Do not carry him in a blanket face up.

Leg Fractures

The quickest way to splint a broken bone in a leg is to tie both of the victim's legs together both above and below the break. The uninjured leg serves as a splint for the fractured leg. This method is good if the patient must be moved in a hurry.

If time permits, a good splint for the lower part of the leg can be made by using two long sticks or poles. The poles should be rolled in a soft cloth material to act as padding for the legs. Bind the splint firmly in several places. Splints should extend from a point well above the knee to a little below the foot.

Hip and Thigh Injuries

Splints for fractures of the hip and thigh are improvised in the same manner as splints for a leg fracture. The inside splint should extend from the crotch to a little below the foot and the outside splint should extend from the armpit to a little below the foot.

Broken Necks

The life of a person with a broken neck is in extreme danger. Just as in the case of a broken back, bone fragments may cut the spinal cord. Keep the patient's head still and straight. You can keep the patient's head and neck motionless by placing heavy objects such as stones at each side of the head as supports. Place rolled clothing or a rolled blanket under the neck for support and padding. To place the roll under the neck, raise the shoulders. Do not bend the neck forward. DO NOT twist or raise the head under any conditions. Leave the person absolutely motionless and treat for shock.

Treatment for Burns

Severe burns are more likely to cause shock than other types of wounds so be sure to treat for shock whenever a person has been severely burned.

Infection is another great danger in cases of severe burns. To get clothing away from the burn, cut or tear the clothes, then gently lift them off. Do not pull the clothing over the burn and do not try to remove pieces of cloth that stick to the burned area.

If large sterile dressings are available, burned surfaces may be covered, but in the case of severe burns it is best to leave the burn exposed. Never break the blisters or touch the burn.

The victim of burns should drink a lot of water because of the loss of body fluids. If possible, add salt tablets or loose salt to the water. Three or more quarts of water should be consumed by the burned victim every 24 hours. Again medical personnel must be summoned at the earliest possible moment.

Treatment for Electrical Shock

Immediate action must be taken in cases of electric shock. Seconds count as they can mean the difference between death and recovery. Artificial respiration is the fundamental first aid measure for this emergency. A person coming in contact with a "live wire" is the usual cause of electrical shock. If the switch is nearby, turn it off, but do not spend time hunting for the switch. Remove the victim from the wire by using a dry wooden pole, dry clothing, rope, or any non-conductor. Be sure not to touch the wire or victim with your bare hands or you will end up in the same condition as the victim. Artificial respiration should be started immediately after freeing the victim from the wire.

HEART-LUNG RESUSCITATION

Resuscitation procedures described herein are in two parts; which, when combined, constitute heart-lung resuscitation. These procedures are applicable to victims of electrical shock, heart failure, drowning, suffocation, and certain other causes; however, the original consideration here is electrical shock.

Artificial respiration is applicable where respiration has stopped, but there is a pulse however slight. The easiest place to detect the pulse is not in the wrist, but in the throat on either side of the windpipe near the collarbone. In cases where no pulse is apparent, use closed chest cardiac massage along with artificial respiration.

Closed chest cardiac (heart) massage is the rhythmical compression of the heart without opening the chest by surgery. It is designed to provide an artificial circulation in order to keep blood flowing to the brain and other organs until the heart's beat has been re-established. Closed chest cardiac massage is used in cases where the heart has stopped beating (cannot detect a pulse).

The primary reason for the heart's ceasing to beat is insufficient oxygen to the vital centers. This could result from smothering. Other reasons include electrical shock, excessive bleeding, shock, heart disease, effects of certain drugs, and even anxiety.

When the heart stops beating or breathing stops, it is always an emergency. Be calm; think; act! Time is of the utmost importance - SECONDS COUNT! If you are alone, or there are only two of you to conduct emergency aid, DO NOT TAKE THE TIME TO SEND FOR HELP. If additional personnel arrive, then send for medical personnel. The great danger when the heart or breathing stops, is the lack of sufficient oxygen carried in the blood to feed the brain. The brain is the most sensitive tissue of the body and the results of a shortage of oxygen becomes severe within a few minutes (usually about three) after breathing and circulation are cut off. Thus, while a victim who has had delayed resuscitation may live, he faces the possibility of extensive brain damage - a human vegetable.

Mouth-To-Mouth Method

This method of artificial respiration is accomplished by executing the procedure listed below.

1. Place the casualty on his back (face up). Do not put anything under his head as it may flex the neck, causing the air passages to be blocked.

2. Quickly clear his mouth of any foreign matter by running your fingers behind his lower teeth and over the back of his tongue. Wipe out any fluid, vomitus, or mucus (see Figure 20). This cleaning should not take more than a second or two since little time should be lost in getting air into the casualty's lungs.

3. If available (do not waste time looking for these materials) place a rolled blanket or some other similar material under the shoulders so that the head will drop backward. Tilt his head back so that the neck is stretched and the head is in the "chin-up" position (see Figure 21). This aligns the air passages so that they do not become blocked by kinking or pressure.

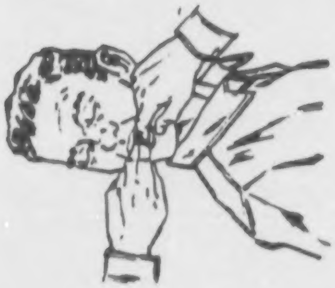

Figure 20. Clean Victims Mouth

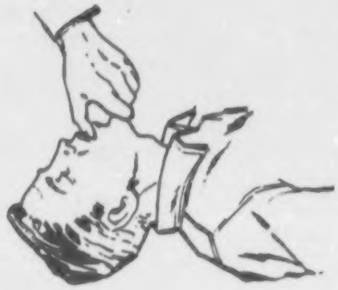

Figure 21. Position Head and Lower Jaw

4. Place your thumb into the corner of his mouth and grasp the lower jaw firmly. Lift the lower jaw forward to pull the tongue forward out of the air passage. Do not attempt to hold or depress the tongue.

5. With other hand, pinch the nose shut in order to prevent air leakage.

6. Take a deep breath and open your mouth wide. Seal your mouth around the casualty's mouth and your thumb, and blow forcefully (except for infants and small children) into his mouth until you see his chest rise (see Figure 22). If the chest does not rise, hold the jaw up more forcefully and blow harder while making sure there is no blockage of the air passage and no air leakage around the mouth or nose.

7. When his chest rises, stop blowing and quickly remove your mouth from his. Take another deep breath while listening for his exhalation. If his exhalation is noisy, elevate the jaw further.

8. When exhalation is finished, blow in the next deep breath. The first five to ten breaths must be deep (except for infants and small children) and given at a rapid rate in order to provide rapid reoxygenation. Thereafter, continue breathing at a rate of 12 to 20 times a minute.

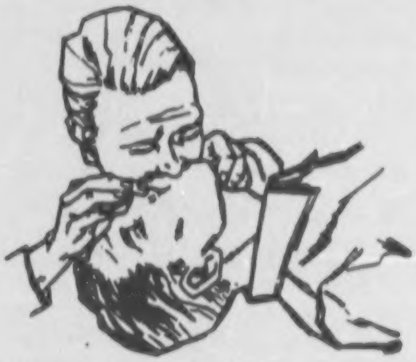

Figure 22. Apply Mouth-to-Mouth Respiration

CAUTION: Excessively deep and rapid breathing may cause you to become faint, to tingle, and even to lose consciousness. Therefore, after the first five to ten breaths, adjust your breathing to a rate of 12 to 20 times a minute with only moderate increase in normal volume. In this way rescue breathing can be continued for long periods without fatigue.

9. After performing rescue breathing for a period of time, you may notice that the casualty's stomach is bulging. This is due to air being blown into the stomach instead of the lungs. Although an inflation of the stomach is not dangerous, it makes inflation of the lungs more difficult. Therefore, when you see the stomach bulging to a marked degree, apply gentle pressure to the stomach with your hand between inflations.

10. As soon as artificial respiration has been started and while it is being continued, an assistant should loosen any tight clothing about the casualty's neck, chest, or waist. KEEP THE PATIENT WARM.

11. Continue artificial respiration without interruption, until natural breathing is restored or until a physician declares the patient is dead.

12. To avoid strain on the heart when the patient revives, he should be kept lying down and not allowed to stand or sit up. He should be kept warm. Give him a warm drink, such as coffee or tea.

13. A brief return of natural respiration is not a certain indication for stopping the resuscitation. Not infrequently the patient, after a temporary recovery of respiration, stops breathing again. The patient must be watched, if natural breathing stops, artificial respiration should be resumed at once.

Closed Chest Cardiac Massage

It is imperative that blood circulation be maintained while the mouth-to-mouth respiration is being performed. A quick method of determining if the heart has stopped beating is to lift the victim's eye lid and observe the pupil. If the pupil is dilated (enlarged), the heart has stopped beating and artificial blood circulation must be maintained throughout the revival procedure, or until natural heart beat is re-established.

Follow the procedure listed below to establish and maintain circulation.

1. Lay the patient face up on a solid support, such as the floor, ground or pavement. A bed or couch is too soft.

2. Clear the patient's throat and mouth of any foreign matter.

3. Begin mouth-to-mouth resuscitation simultaneously with heart massage. If two people are available, one give mouth-to-mouth resuscitation while the other gives closed chest cardiac massage (see Figure 23). If only one person is available, alternate eight counts of cardiac massage with two counts of mouth-to-mouth breathing.

4. Kneel at right angles to the patient's trunk so you can use your weight in applying pressure.

5. Place the heel of your right hand on the breastbone of the patient, with fingers spread and raised so that pressure is only on the breastbone, but not on the ribs (see Figure 24). Place your left hand on top of the right, and press vertically downward - apply enough pressure to depress the breastbone from one and one-half to two inches (see Figure 25). The chest of an adult, although resistant when he is conscious, becomes surprisingly flexible when he is unconscious.

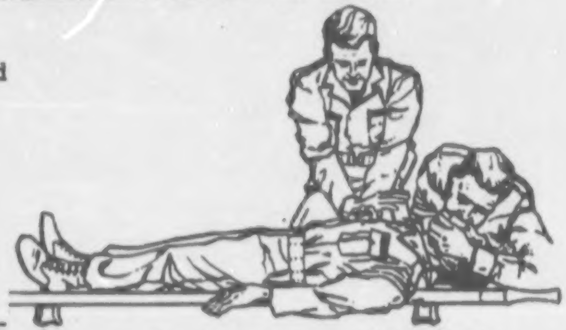

Figure 23. Two Person Heart/Lung Resuscitation Method

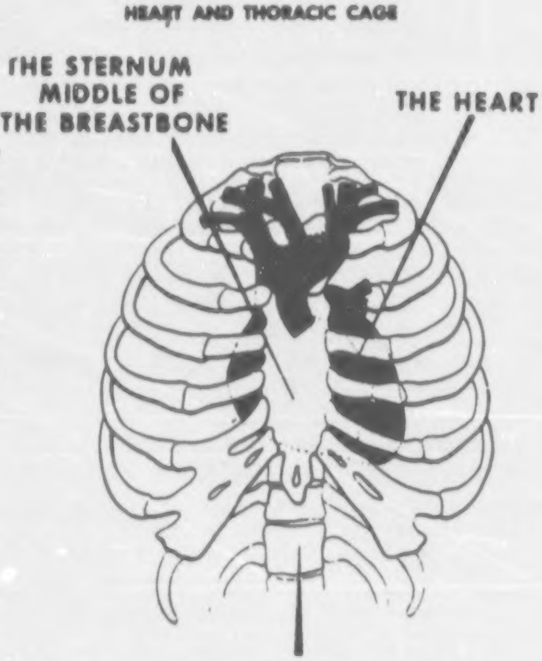

Figure 24. Heart and Thoracic Cage

NOTE: With a child, use only one hand and relatively light pressure. In newborn infants, use of fingers only may be sufficient.

NOTE: The heart is located between the sternum (breastbone) and the vertebral column. Pressure on the breastbone forces the heart against the spine, thus forcing blood into the arteries. Release of pressure allows the heart to refill with venous blood.

6. Release the pressure immediately, lifting the hands slightly (see Figure 26), then repeat in a cadence OF APPROXIMATELY 60 THRUSTS PER MINUTE.

7. Continue closed chest cardiac massage until you get professional medical aid. Also, if possible, continue to give mouth-to-mouth resuscitation until someone arrives with a tank of oxygen to take over. If you are on your own and the victim shows no response, continue both measures until the victim becomes stiff (rigor mortis sets in). Even trained and experienced medical personnel find it increasingly difficult to say when a person is really dead beyond recall. Again, the most important point is to immediately begin and continue resuscitation efforts.

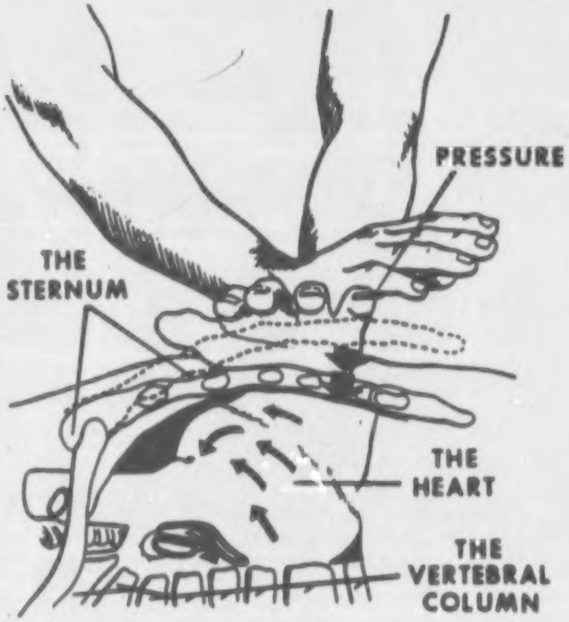

Figure 25. Pressure Forces Blood out of Heart

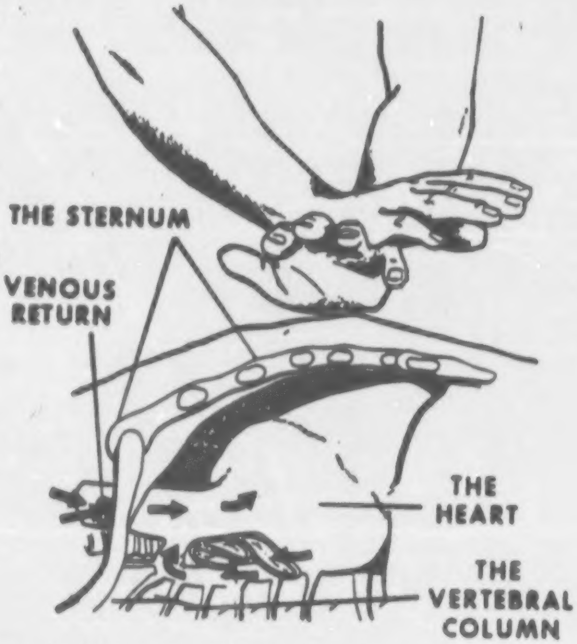

Figure 26. Release Pressure, Heart Refills

Back Pressure-Arm Lift Method

The back pressure-arm lift method of artificial respiration is shown in Figure 27. This method may be used when the victim has suffered mouth injuries, or when vomiting is occurring.

Back Pressure-Hip Lift Method

This is another method of artificial respiration which may be used when the Exhaled Air Method is not desirable, and when arm injuries prevent the use of the Arm Lift Method, (see Figure 28).

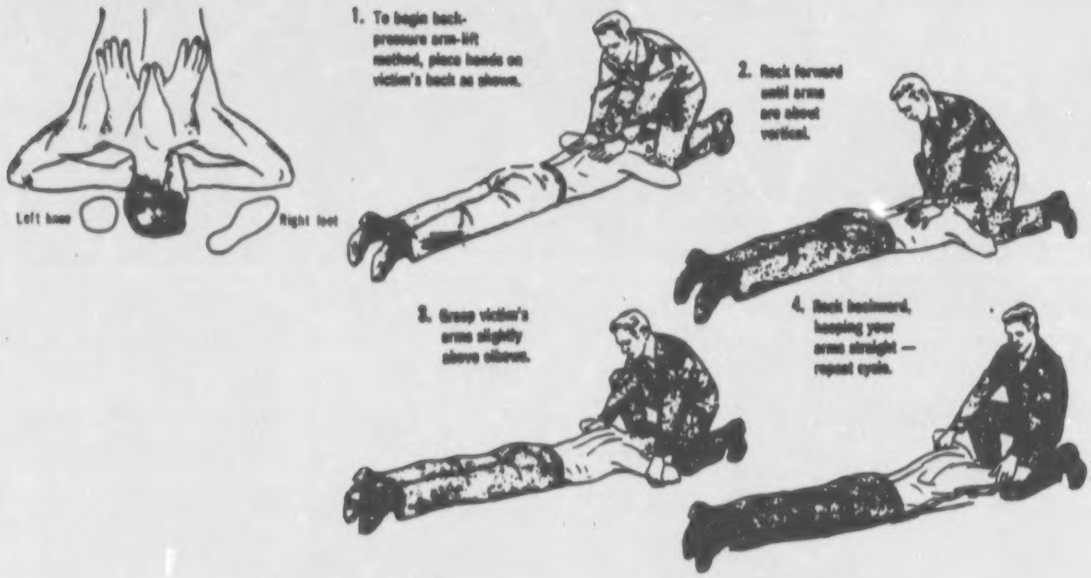
Left knee
Right foot
1. To begin back-pressure arm-lift method, place hands on victim's back as shown.
2. Rock forward until arms are about vertical.
3. Grasp victim's arms slightly above elbows.
4. Rock backward, keeping your arms straight — repeat cycle.

Figure 27. Back Pressure - Arm Lift Method

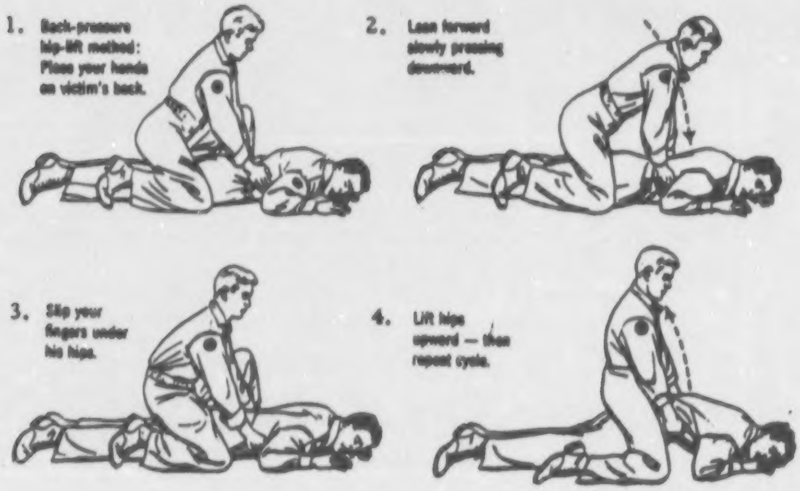
1. Back-pressure hip-lift method: Place your hands on victim's back.
2. Lean forward slowly pressing downward.
3. Slip your fingers under his hips.
4. Lift hips upward — then repeat cycle.

Figure 28. Back Pressure - Hip Lift Method

EMERGENCIES FROM TOXIC SUBSTANCES

AFM 127-101 should always be consulted for current information relative to chemical hazards. As an airman, you can expect to come in frequent contact with potentially dangerous substances. Fuels, solvents, and fire extinguishing agents are examples of such materials. Over-exposure to these, and many other substances, can result in severe illness or death. Remember, the early effects of toxic substances are often difficult to detect; So Be Alert!

Fuels

Some fuels may present a potential hazard. Look for these symptoms in yourself and others: drowsiness, headache, lassitude, a sense of well being and buoyancy, excitement and disorientation; and then, in a later stage a reduced level of consciousness, convulsions, and finally coma. Immediately remove a person to fresh air if he develops any of these symptoms. Normally, fresh air is all that is needed for mild contamination. If clothing has been saturated with fuel, remove the affected clothing. Cleanse the skin immediately with large amounts of water.

If the victim is found unconscious, remove him to fresh air and give him oxygen if available. Keep him warm. Give artificial respiration if he is not breathing and get medical help as soon as possible. The best first aid for toxic fuel, as for all toxic substances, is to practice correct preventive measures.

Solvents

Solvents compose another group of chemicals that often prove toxic. As is true in any case of toxic posioning, immediately remove the victim from the contaminated area, remove any clothing that is saturated, and throughly wash the contaminated skin.

PREVENTION OF ADVERSE EFFECTS OF HEAT

When working under high temperature conditions, there are several important precautions that you should take to prevent heat cramps, heat exhaustion, or heat stroke. Your ability to quickly recognize the symptoms of each and provide the correct treatment may save your life or the life of your fellow worker.

The symptoms, effects, treatment, and prevention of the adverse effects of heat are presented in the following topics.

Heat Cramps

A cramp is the result of excessive loss of body salt by perspiration. The cramp may occur in the arms, legs, and stomach. The body temperature will usually remain normal.

This condition is relieved by replacing the salt lost from the body through the administration of a salt solution by mouth. This condition also requires rest.

Heat Exhaustion

Heat exhaustion is the result of excessive loss of water and salt from the body. It is characterized by profuse perspiration, coolness of the skin, low blood pressure, fast pulse, extreme weakness, nausea, headache, staggering, mental confusion, pale skin, and occasionally, leg and stomach cramps. Mild cases recover rather promptly under rest alone, but death due to circulatory collapse is not uncommon.

Treatment consists of moving the individual to a cooler place to rest, elevate his feet, massage his arms and legs, and give him water and salt as freely as he will take it.

Heat Stroke

Heat stroke is a very serious condition with a high mortality rate. It is the result of the breakdown of the body's heat regulating mechanism. The early symptoms are the same as for heat exhaustion, except that the individual's skin will be hot, red, and dry and there will be absence of perspiration. However, the onset of heat stroke may occur with dramatic suddenness and there will be collapse and loss of consciousness. Convulsions may occur and the body temperature will be high. Death may occur suddenly.

Treatment

The lowering of the patient's body temperature as rapidly as possible is the most important objective in the treatment of heat stroke. The longer he remains in stroke, the greater the threat to life. Remove the patient's clothes. If there is any source of cool water, he should be submerged; otherwise, water should be sprinkled over him and its evaporation hastened by fanning. Massage the extremities and trunk of the body. It is very important to get him to the hospital immediately.

Prevention

By now you should realize that over-exposure to heat is a very serious thing, and that recognition of the symptoms and knowledge of first aid treatment is essential. But most important is the knowledge of prevention measures. They are simple and no one need ever suffer the effects of cramps, exhaustion, or stroke. The first rule is to drink plenty of water, at least 8 ounces per hour, more if you prefer. Take four to six salt tablets per day. One important note about salt tablets - Never take a salt tablet without a drink of water. It may cause nausea and vomiting.

Keep yourself in the best of physical condition and the chance for any adverse effects will be greatly lessened.

Regardless of physical condition, a person who is suddenly exposed to extreme heat must pass through a period of acclimatization. Strenuous work during this time should be limited. Work periods must and should include alternating work and rest periods. Most individuals become fully acclimatized after five or six days' exposure.

Remember, it is easy to prevent the adverse effects of heat. Replenish the water and salt lost through perspiration as the losses occur. Drink water and take salt tablets.

Asbestos Exposure

In May 1974 the Air Force Surgeon General's Office issued, through medical channels a preliminary occupational health standard on asbestos exposure (SG ltr, "Asbestos Exposure," 8 May 74). The standard provides airborne concentration limits, methods of compliance, environmental monitoring requirements and procedures, and guidance on personal protective equipment.

The burden of determining compliance with this standard rests largely on the medical service; however, assistance by the ground safety staff and supervisors is strongly encouraged. For example, assistance in locating operations involving potential exposure to asbestos dusts is greatly needed.

At first thought it might be assumed that asbestos usage is extremely limited in the Air Force environment. Perhaps pipe insulation in an old building might create a problem when these buildings are repaired or demolished. However, a glance through the General Services Administration catalog indicates a wide availability of asbestos products. There are numerous stock-listed items in the 5330, 5640, and 5650 Federal Stock Classes that contain asbestos, such as:

Manhole gaskets
Packing material
Tape, asbestos
Cement, asbestos
Insulation, pipe
Honeycomb paper
Insulation felt, thermal
Millboard, asbestos
Paper, asbestos
Shingle, asbestos cement

Normal use of these materials is not likely to result in an exposure to airborne concentrations of unbound asbestos fibers approaching limiting values, but the possibility cannot be ignored. Personnel who work with asbestos materials should be made aware of the health hazard potential that asbestos poses, and instructed in preventive and protective measures.

SUMMARY

First aid is the treatment given to an injured person before medically trained personnel arrive. A working knowledge of first aid may mean the difference between life and death of an injured person. Know how to recognize the different types of injuries, wounds, and the proper treatment for each. Good common sense and adherence to safety rules will keep your work as a first aid man to a minimum.

QUESTIONS

1. What are the three life-saver steps that should be carried out when treating a wounded or injured person?

2. What is shock?

3. What are the different types of fractures?

4. What is the best method of giving artificial respiration?

5. When should an injured person be moved?

6. To what extent should you attempt to render medical aid?

7. What is the best treatment you can give for shock?

8. What is generally the best method of reducing bleeding?

9. Who should attempt to set broken bones?

10. What is the most important first aid to undertake in case of severe burns?

REFERENCES

1. AFR 127-101, Ground Accident Prevention Handbook

2. AFP 85-1, Electrical Facilities Safe Practices Handbook

SECTION V

SAFETY AND HUMAN RELIABILITY PUBLICATIONS

Selected safety publications are presented to you in this section in alphabetical/numerical order; they are Manuals (AFMs), Pamphlets (AFPs), and Regulations (AFRs). These are simply for presentation order and does not indicate that one publication is more important than another. They are all important to your well-being. Get acquainted with them.

Probably the most important thing you can learn about AF manuals, pamphlets, and regulations from this section is that they are indexed in Air Force Regulation 0-2. AFR 0-2 is the Numerical Index of Standard Air Force Pbulications. Another index of real importance to you is AFR 0-6, Subject Index of Air Force Publications. Remember you can locate the number, title, and date of any standard Air Force regulation, manual, or pamphlet in the index, AFR 0-2.

AFM 35-99, HUMAN RELIABILITY PROGRAM

This manual establishes the requirements and responsibilities for screening, selecting, and continuously evaluating all personnel who control, handle, have access to, control launch of, or control access to nuclear weapons, nuclear weapon systems. It provides for the selection and retention of personnel who are physically and emotionally sound and reliable, and have demonstrated good judgment and professional competence. It also provides procedures for reassignment or separation of individuals found to be unreliable for such duties.

The objective of the Human Reliability Program is to eliminate, as far as possible, the occurrence of acts which could lead to an unauthorized detonation of a nuclear weapon or unauthorized launch of a missile/aircraft carrying nuclear weapons. This objective can be accomplished by screening, selection, continuing education, and surveillance of individuals assigned to positions where they might gain access to, and knowledge of, a nuclear weapon system.

AFM 127-100, EXPLOSIVES SAFETY MANUAL

This manual has been developed to cover all Air Force explosives operations. If you are required to participate in any explosives or demolition operations, you should do so only after careful review of AFM 127-100.

AFR 127-101, GROUND ACCIDENT PREVENTION

This is an Air Force regulation which presents comprehensive and detailed guidance for personnel in the areas of safety, accident prevention, and first aid. It is a very useful, and easy-to-use regulation. Its ease of use stems from the very detailed alphabetical index in the back. Since it is so easy to use and since it contains so much needed information, you must become familiar with this valuable document.

To give you some idea of the coverage of AFR 127-101, the table of contents is shown as follows:

Chapter

1 - Introduction
2 - Ground Accident Prevention Program
3 - Principles of Industrial Shop Safety
4 - Safe Practices in Operation and Maintenance of Base Facilities and Construction
5 - Health Hazards and Protection
6 - Fire Prevention
7 - Liquid Propellants and Hazardous Materials
8 - Aircraft and Flight Line Safety Practices
9 - Safety in Railroad Operations
10 - Electrical Facilities, Electronic Equipment, Lasers and Masers
11 - Safety in Motor Vehicle Operations
12 - Safety in Materials Handling
13 - Recreational and Off-Duty Activities
14 - Medical Facilities

AFM 127-201, MISSILE ACCIDENT PREVENTION

This manual provides general, basic information on hazards involved in operating and maintaining missile systems, and describes measures for preventing mishaps. It explains how to operate missile systems and prepare safety survey checklists. It applies to all Air Force installations.

The Missile Accident Prevention handbook is a very interesting and informative manual dealing with the hazards and safety procedures at missile installations. If you are assigned to duty at a base having missiles, and you very well may be, be sure to familiarize yourself with AFM 127-201. It is also indexed in AFR 0-2. Use it and learn the fine art of self-protection, and protection of USAF equipment.

AFP 85-1, ELECTRICAL FACILITIES SAFE PRACTICES HANDBOOK

This pamphlet prescribes safe practices and procedures for personnel engaged in maintaining and operating electric systems and facilities. The size of this pamphlet has been designed to facilitate ready reference by workmen on the job. It is pocket-size.

The rules and recommendations contained in AFP 85-1 are directive in nature and will be followed at all Air Force installations.

This pamphlet is especially useful to all personnel who work on or around electrical equipment or systems. It is a relatively small, pocket-size booklet which is easily carried and easily used right on the job. Along with many safety precautions to observe when working with electrical equipment or systems, this pamphlet prescribes the procedures for first aid, and heart-lung resuscitation. This includes instructions for mouth-to-mouth artificial respiration and for closed chest cardiac massage.

AFP 85-1 is a highly useful booklet for all who are exposed to electrical systems operation or maintenance. Take time to study the one in your file, and if you work with electricity, try to get a copy for your individual use. Your publications clerk can get you one.

AFR 50-24, TRAFFIC SAFETY EDUCATION

This regulation prescribes a Traffic Safety Training Program for Air Force officers, airmen, and civilian personnel. Again, knowledge of this regulations will help you understand why you have to attend driver training. The Air Force needs you alive and in good condition, and conducts an extensive safety program to keep you this way.

AFR 122-1, THE AIR FORCE NUCLEAR SAFETY PROGRAM

This regulation explains the Air Force Nuclear Safety Program. It assigns responsibilities to those HQ USAF offices and major commands concerned with nuclear weapon systems (US Air Force or ally-operated), nuclear power systems, or logistic movement of nuclear weapon cargo. This regulation is not intended to restrict equipment and procedures presently used for support of nuclear systems or logistic movement. However, after the date of this publication, any proposed change or modification to existing procedures or equipment that could affect nuclear safety must conform with this regulation.

AFR 122-4, THE TWO-MAN CONCEPT

This regulation establishes the Two-Man Concept, the primary purpose of which is to enhance nuclear safety during nuclear weapon/nuclear weapon system operations. It applies to all organizations assigned to mission or function involving nuclear weapons or nuclear weapon systems.

AFR 122-5, SAFING AND SEALING

This regulation requires that a major command with an operational nuclear weapon responsibility develop appropriate procedural directives to meet safing and sealing requirements of Nuclear Weapon System Safety Rules.

AFR 127-4, INVESTIGATING AND REPORTING USAF ACCIDENTS/INCIDENTS

This regulation combines all accident, incident, and nuclear deficiency reporting and investigative requirements in the fields of aircraft, ground, explosives, missile, and nuclear safety. It states policy, explains terminology, establishes responsibilities, and prescribes procedures. It tells how to report a USAF accident including the Air Force Reserve.

The important part about this regulation is to know what to do if you are the first person at the scene of a mishap.

First Military Personnel at Scene of Mishap

The first military person reaching the scene, if the situation requires, will:

1. Secure necessary medical services or identification assistance, as required.

2. Report by telephone or the most expeditious means all known facts to the nearest Air Force installation.

3. Obtain names and addresses of all available witnesses (including rank, SSAN, organization, and station of all military personnel) whose testimony may aid the investigation.

4. Until relieved or otherwise instructed by competent authority, do whatever is necessary to make sure that the wreckage is not moved or tampered with in any way, except to assist or remove persons injured or killed, and eliminate any further danger.

5. Establish the necessary guard as follows:

   a. If mishap occurs at or near a US military installation, obtain the guard from its commander.

   b. If mishap is not near a US military installation, obtain the guard from civilian sources at the local rate of pay. The use of civilian guards does not cancel the security responsibilities of the senior military person at the scene of the mishap.

   c. Enlist aid of local law enforcement agencies.

6. Shield from public view or photography, documents or material known or suspected to be classified.

The above procedures apply upon recognizing that an accident or incident has occurred. Personnel encountering these situations must take the immediate actions indicated above. It is unlawful to leave the scene of an accident unless properly dismissed.

The formal reporting of accident is the responsibility of the commander concerned. Prior to submission of formal reports, he will appoint an accident investigating officer or officers, who will conduct a thorough investigation to insure that reports submitted are accurate.

AFR 127-5, USE OF PROTECTIVE EQUIPMENT BY VEHICLE OPERATORS AND PASSENGERS

This regulation cites the requirements and prescribes specifications for seat belts and protective (crash) helmets for riding Air Force-owned motorcycles or similar vehicles, motor scooters, etc. A shatterproof eye protector must be worn with the helmet. Center directives usually will require the same safety equipment for on-base registration of private motorcycles or similar vehicles. This again is an example of the concern that USAF has for its personnel, both on and off the job.

AFR 127-6, THE USAF HAZARD REPORTING SYSTEM

This regulation outlines the purpose, functional scope, and responsibilities of hazard reporting within the USAF. It also outlines the reporting procedures. Under the terms of this regulation, a reportable hazard is considered to be any condition, act or circumstance that jeopardizes or may jeopardize the safety of personnel, weapon systems, facilities or equipment, when the condition is not a part of a reportable accident, incident, or deficiency.

SUMMARY

The regulations, pamphlets and manuals treated in this study guide are very important to you and to your next assignment. However, there are many publications pertaining to safety. While coverage of all these publications is impractical in this publication, always remember that all Air Force regulations, manuals, pamphlets, and letters are numerically indexed in AFR 0-2 and that the "subject" index is AFR 0-6. In addition, safety-type publications are also included in the Technical Order System, particularly in the TO 00-25 Series.

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